NASA Tech Briefs

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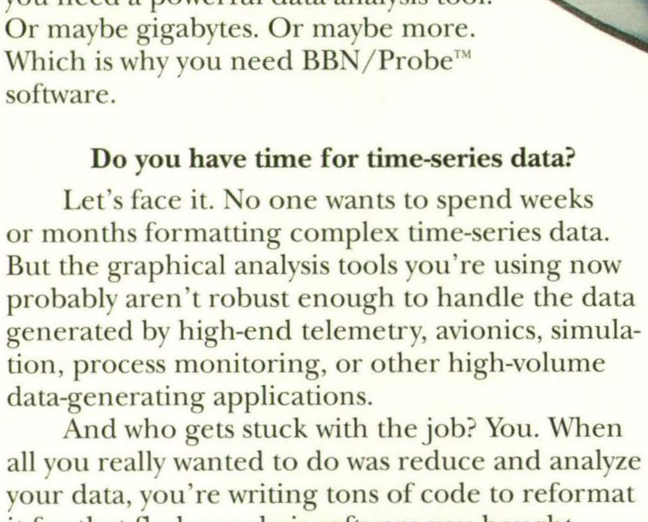

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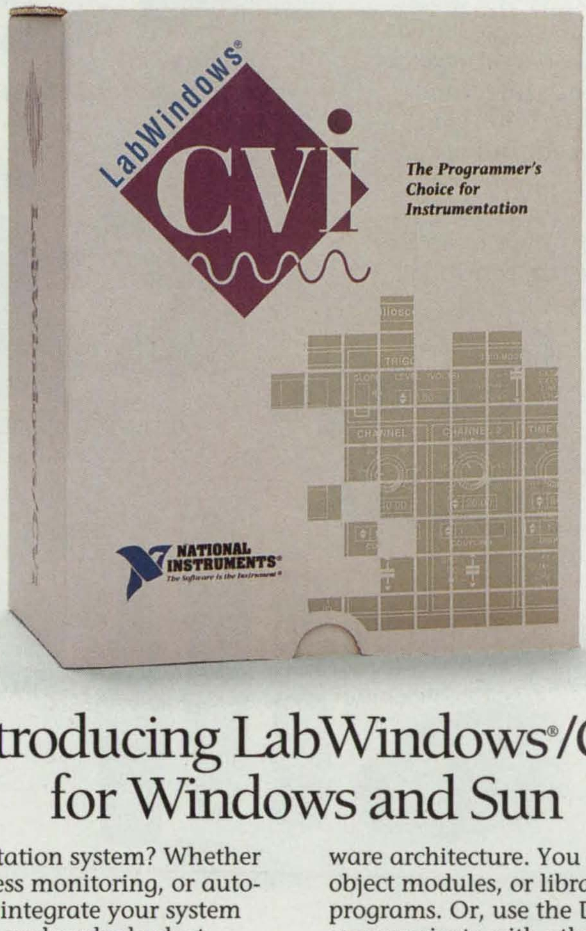

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DEPARTMENTS

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On the cover:

Teleoperated robots such as Jet Propulsion Laboratory's HAZBOT III can relieve humans from the risks associated with hazardous waste removal, bomb detection, and a wide range of dangerous tasks. New features, including all-solid-state electronics, brushless motors, and a pressurized chassis, enable this latest HAZBOT design to operate in combustible environments and thereby aid in fire-fighting. Turn to NASA's Innovators on page 14.

Photo courtesy of Jet Propulsion Laboratory

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NASA's INNOVATORS

Technology 2003, the fourth national technology transfer conference and exposition (December 7-9, Anaheim convention center), will feature presentations by more than 50 of NASA's leading technologists detailing a broad array of commercially-promising inventions and processes. In the first of two parts, we highlight some of their cutting-edge work.

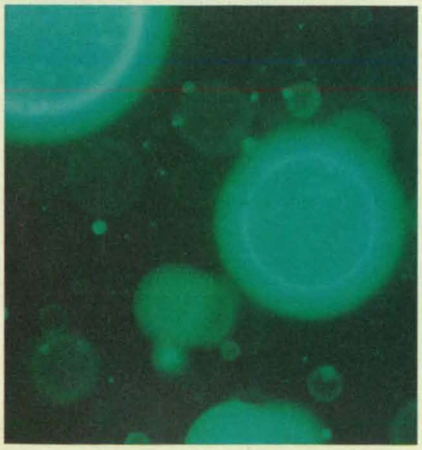
Space-based Drug Delivery System

Microencapsulation technology offers a novel approach to delivery of medicinal drugs. Captured within semipermeable microcapsules, drugs such as anti-tumor, antibiotic, and thrombolytic compounds can be injected directly at specific sites within the human body and then time-released by diffusion.

Problems have arisen, however, in producing microcapsules of uniform size and shape that contain a high concentration of the drug—all critical factors for proper drug distribution and effectiveness. A new encapsulation method, developed by researchers at Johnson Space Center and Encap Inc. and demonstrated on four space shuttle missions, takes advantage of the surface-free energies of liquids in microgravity.

"When forming microcapsules on Earth, you're constantly fighting gravity-dependent phase separation of the liquids due to their independent density differences," said Dennis Morrison, a senior biotechnology scientist at Johnson. "In microgravity, there are no density differences, so you can control the formation of different layers as well as what they contain."

Innovative microcapsules filled with an anti-tumor drug could be injected directly at a target tumor site. The drug resides in both the outer and inner layers of the capsule for sustained release through its semipermeable membrane.



First, bioactive drugs are dissolved in a water solution and mixed with a hydrocarbon solvent. Through liquid-liquid diffusion in microgravity, the two solutions separate to form spheres less than 100 µm in diameter. Next, the microspheres are exposed to waxy lipids, which help to cure a permeable outer skin for the microcapsules. Though flexible, the skins are tough enough to provide adequate suspension and preservation of the inner layers, as well as durability for future storage and administration.

The drugs in the aqueous layer can be encapsulated just inside the outer skin, as well as within the innermost layers of the microcapsules, to provide sustained release of the drug treatment. "We've created microcapsules with maximum drug payload to achieve the highest therapeutic effect," said Morrison.

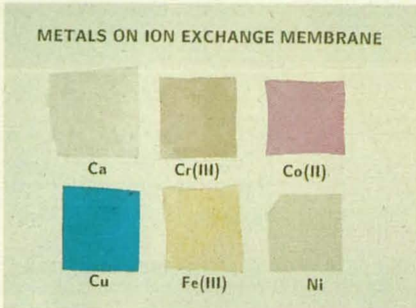
The technique has been employed successfully to form microcapsules containing Cis-platinum (an anti-tumor drug), amoxicillin (an antibiotic), and urokinase (a clot-dissolving enzyme). These water-soluble drugs were co-encapsulated with poppy seed oil, a radio-contrast medium, to enable position tracking of the microcapsules within the body using a CT scanner.

In the future, interarterial injection of these capsules near target sites may provide treatment for such illnesses as cancer, blood clots, and deep infections. Delivering the drugs directly to specific sites decreases the chances for dilution in the bloodstream or dispersion to other parts of the body, while timed release of the drug reduces systemic side effects.

Researchers are investigating how the formation of alternate hydrophobic and hydrophilic layers during microgravity production can permit inclusion of two or more different drugs in one capsule. This capability may enable development of multiple-therapy capsules that can sequentially administer a variety of drug treatments. According to Morrison, future experiments will attempt to mimic the success of microgravity encapsulations with ground-based technology.

New Material Could Aid Environmental Cleanup

A high-capacity ion exchange material (IEM) developed at Lewis Research Center can remove toxic metals from contaminated water and may provide a low-cost medium for a wide range of filtering systems. Formed into thin films, coatings, pellets, or fibers, the IEM could be adapted for purification in waste water treatment plants, lakes, ponds, industrial plants, or homes.

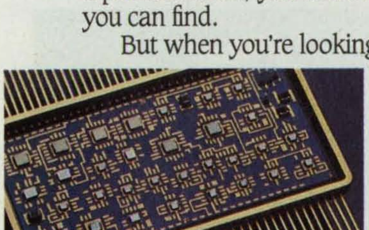


An ion exchange material developed at Lewis Research Center adsorbs a range of heavy metal ions from water, turning distinct colors depending on the ion (as shown above). Color intensity provides a key to ion concentration.

Industries such as electroplating and mining produce large amounts of waste water containing hazardous levels of mercury, lead, cadmium, silver, copper, and zinc ions. According to Kenneth Street, chief of Lewis' Chemical Sampling and Analysis Branch, current technologies for reducing the concentrations of these toxic metals appear inadequate for meeting newly established limits.

The material's affinity for heavy metal ions was discovered during its development as a battery separator for space use. "Dr. Warren Philipp [a co-investigator] was washing samples with distilled water and couldn't figure out why they were turning blue," recalled Street. "It was because the copper tubing in his distilling unit had gone bad—the copper was leaking through and turning the resin blue."

A team was assembled to test the material on other metal ions and found that, in addition to purifying the water to below EPA limits, the material can be used to both identify the toxins and measure their concentration levels.



Individual metal ions—such as calcium, chromium, cobalt, copper, lead, and nickel—turn the IEM a particular color, with higher concentrations producing more intense hues. Research continues to determine adsorption rates and quantities adsorbed per unit weight with respect to different metals. The researchers recently determined that the film works well on lanthanide ions, which are used as non-radioactive models for the chemical behavior of the highly radioactive actinides.

The patent pending material's most important feature is its ability to adsorb other metals in the presence of calcium ions, which can saturate and render ineffective many ion exchange materials. This capability confirms the IEM's potential as a home water filtering medium, as calcium is the active ingredient in hard water.

According to Street, there is a pressing need for an inexpensive home unit to remove highly-toxic lead from water flowing past lead solder in older homes. "In tests with drinking water, we put in 150 parts per billion and the material took it down to two parts per billion—way below the EPA's acceptable levels," said Street. "A new filter should last about a year or two and cost just five to ten dollars to replace."

Tests have shown that the IEM is easy to use, inexpensive to make, and both flexible and resistant to tearing. It also is chemically stable in storage, aqueous solutions, and in acidic or basic solutions. An Ohio electroplating firm is testing the material's effectiveness in a zinc plating process.

The Lewis team is working with the departments of Energy and Defense and the EPA to implement ion exchange technology in magnetic separations. The technique could serve as a replacement for packed column technology, in which sludge can plug up the tube and stall the water's flow. According to Street, the method could enable massive water cleanup—on the order of thousands of liters per minute.

Where There's Danger, Call HAZBOT

It's a tough job, but something has to do it.

HAZBOT, a teleoperated mobile vehicle developed at the Jet Propulsion Laboratory, will help HAZMAT teams find, identify, and handle hazardous materials without risking personnel, and recently was adapted for another dangerous job—fire-fighting.

HAZBOT is part of JPL's Emergency Response

HAZBOT III, pictured here with its operator control system, is JPL's mobile robot designed for safe handling of hazardous materials. The vehicle recently was redesigned for use in fire-fighting.

Robotics Project, a five-year effort begun in 1991 to apply robotics technology to the safe handling of hazardous materials. Robots such as HAZBOT also hold potential for use in mining and law enforcement.

"It's almost standard now to have robots on bomb squads in major cities—but it took several years for the idea to catch on," said Richard Welch, task manager of Emergency Response Robotics at JPL. "We hope that by demonstrating their utility for fire-fighting, we can establish a market."

HAZBOT III, based on the commercially-available REMOTEC ANDROS V robotic vehicle, was significantly redesigned with input from the JPL fire department for operation in combustible environments. It incorporates all-solid-state electronics, brushless motors, and a special chassis and manipulator design to allow positive pressurization of all areas containing electronics and motors.

Small enough to maneuver in tight surroundings, the vehicle has a "tank-like" track drive with articulated front and rear sections to enable it to climb stairs and other obstacles. A six-degree-of-freedom manipulator has a 30-pound lift capability and allows the robot to perform a variety of tasks including the unlocking and opening of doors. The manipulator also incorporates a parallel jaw gripper with a 60-pound squeeze force and a gas detector to aid in material identification.

HAZBOT III's sophisticated on-board computer system controls the manipulator, track drives, and camera positioning, and processes the data from temperature, pressure, and chemical sensors. Two video cameras provide feedback to the system operator, one located on the gripper and the other on a movable pan/tilt platform.

"We're considering the addition of stereo vision to correct manipulation problems caused by lack of depth perception," explained Welch. "Also, a simple force sensor in the gripper could prevent the robot from breaking what it picks up."

The operator's control station consists of two video monitors (one for each of HAZBOT's cameras), a control panel to direct the robot's movement, and a display of system information and sensor data. The system is designed to permit future implementation of such features as autonomous tool retrieval or coordinated manipulator motion.

Under the guidance of JPL's fire department and HAZMAT team, HAZBOT has performed successfully in two simulated response missions and soon will begin field testing.

Banishing Duplication in NDE Systems

On tomorrow's factory floor, multiple operations once thought discrete will come together at a single workstation, to be integrated into a whole. That is the underlying concept of concurrent engineering, a notion many observers think will be pivotal in maintaining global competitiveness. This approach wraps product design, manufacturing, process monitoring and control, inspection, service life prediction, and maintenance scheduling into one package.

Work done in Goddard Space Flight Center's Materials Branch has taken an important step in this direction. A research team began with ultrasonic C-scan and eddy-current imaging, the most widely utilized nondestructive evaluation (NDE) techniques for qualification, monitoring, and manufacturing process control. Both are based on the pointwise mechanical scanning process to acquire data and generate images. The two have been united in a single, easy-to-use hardware/software instru-

ment. "The program helps you through various processes and procedures," said materials engineer E. James Chern. "Training would be needed only for setup and interpretation. The operational end is self-explanatory."

The development of application-specific plug-in expansion boards for PCs made possible the combination. The system includes a common mechanical control and data acquisition and image processing software. Measuring instruments are incorporated into the PC platform by using an analog ultrasonic pulser/receiver and a digital eddy-current impedance analyzer, a plug-in eddy-current instrument, a digital multimeter, and an IEEE-488 interface card.

Various sensors such as focused and flat ultrasonic transducers and absolute and differential eddy-current coils shaped for specific applications are used as probes.

A novel nondestructive evaluation tool unites ultrasonic C-scan and eddy-current imaging at a single workstation, an important step on the path toward concurrent engineering.

The Goddard team also found a way to improve data acquisition. The controller of an ideal digital pointwise imaging system, Chern noted, would command the scanner to scan at a desired speed, monitor its position with encoder references, and fetch measurements at the desired coordinates on the fly. Using a Borland C++ 3.1 programming package, they developed interrupt handling routines that signal the programmable multiaxis controller (PMAC) to initiate data acquisition. The scan routine downloads the scan parameters to the PMAC memory along with the position of the first measurement. The remainder of the measurement positions are calculated on the fly relative to the starting position.

Currently, the system requires switching back and forth between its two testing modes. According to Chern, it will be possible in the future to conduct both tests concurrently using a scanning head that will accommodate both probes.

The system's promise, however, extends well beyond the current instrument. "People keep buying different computer systems for different applications," he said. "A system that can be integrated with other hardware can benefit anyone that works with NDE—you just buy a card to slip in a slot. And the overall concept could be applied to processes other than NDE, such as manufacturing and monitoring." ❑

For more information about the technologies described above, contact the NASA field center that sponsored the research (see page 22). The second part of this article will appear in the December issue.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New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Technology Utilization Office of the sponsoring NASA center (see page 22). NASA's patent-licensing program to encourage commercial development is described on page 22.

Imaging Genetic Molecules at Atomic Resolution

In a proposed method, the sequences of component monomers are determined about 103 to 104 times faster than by conventional methods. The method would accelerate research on the genetic structures of animals and plants and contribute significantly to microscopy imaging processes.
(See page 115.)

Edge-Geometry SNS Devices Made of Y/Ba/Cu/O

Featuring desirable electrical characteristics and simpler fabrication, these devices are attractive for development of high-frequency oscillators, magnetic-field sensors, and submillimeter-wave mixers.
(See page 50.)

Continuous Measurement of Mass Density of Yarn

A production version of this instrument could be used for continuous real-time monitoring of such yarn-manufacturing processes as coating or impregnation.
(See page 89.)

Saddle Clamp With Captive Components

A modified saddle clamp prevents parts from falling off when the clamp is installed or removed. It allows easy access for tightening or loosening bolts.
(See page 111.)

Production of Human Antibodies

Human lymphocytes can be taken from any source. The method is potentially applicable to any antigen and does not rely on Epstein-Barr virus.
(See page 116.)

Corrosion-Indicating Pigment and Probes

Applied to critical parts on bridges and aircraft, a proposed paint would change color much earlier than corrosion that becomes visible to the naked eye.
(See page 72.)

Spring-Tab Lock Washer

Unlike conventional split-ring lock washers, this spring-tab lock washer does not dig into the fastened parts.
(See page 110.)

Autonomous Deicing System for Airplane Wing

A "smart" electromechanical system detects ice and knocks it off. Thickness of the ice is monitored continually.
(See page 30.)

HOW YOU CAN BENEFIT FROM NASA's TECHNOLOGY UTILIZATION SERVICES

If you're a regular reader of TECH BRIEFS, then you're already making use of one of the low-and no-cost services provided by NASA's Technology Transfer Program. But a TECH BRIEFS subscription represents only a fraction of the technical information and applications/engineering services offered by this Program. In fact, when all of the components of NASA's Technology Transfer Network are considered, TECH BRIEFS represents the proverbial tip of the iceberg.

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You can contact NASA's network of RTTCs for assistance in solving a specific technical problem or locating technology or markets that match your interests. The RTTCs are experienced in working with industry to define technology needs and acquire and commercialize applicable technology. User fees are charged for most services. **For more information, call 1-800-472-6785** and you will be connected to the RTTC in your geographical region (or you may call or write directly to the RTTC in your region).

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If you are interested in information, applications, research, training, and services relating to satellite and aerial data for Earth resources, contact NASA's transfer point for earth observing technology: **Technology Application Center, University of New Mexico, 2500 Yale Blvd. S.E., Suite 100, Albuquerque, NM 87131-6031; Dr. Stan Morain, Director (505) 277-3622.**

If you represent a public sector organization with a particular need, you can contact NASA's Application Team for technology matching and problem solving assistance. Staffed by professional engineers from a variety of disciplines, the Application Team works with public sector organizations to identify and solve critical problems with existing NASA technology. **Technology Application Team, Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709; *Dr. Doris Rouse, Director,* (919) 541-6980**

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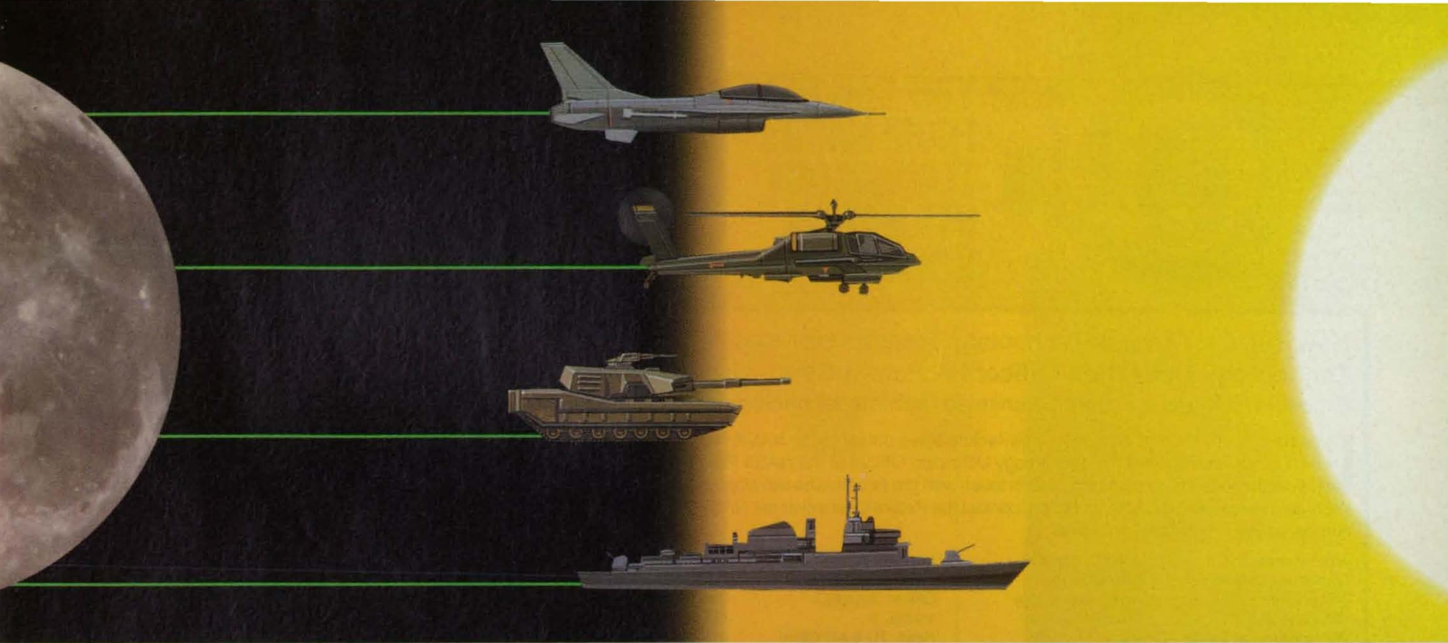
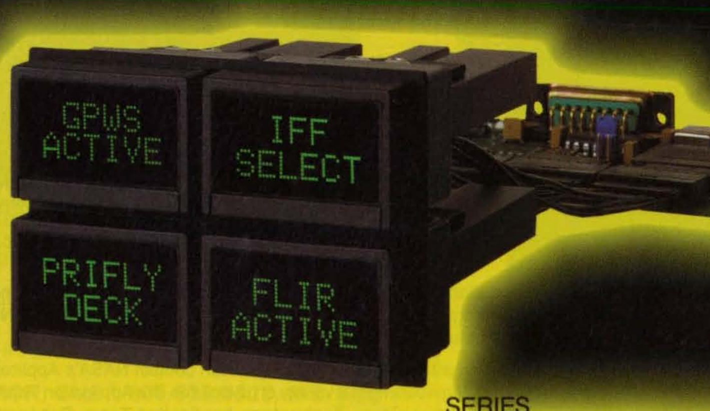
If You Have a Question..**NASA Center For AeroSpace Information** can answer questions about NASA's Technology Transfer Network and its services and documents. The CASI staff supplies documents and provides referrals. Call, write or use the feedback card in this issue to contact: **NASA Center For AeroSpace Information,** Technology Transfer Office, 800 Elkridge Rd, Linthicum Heights, MD 21090-2934. *Walter M. Heiland, Manager,* (410) 859-5300, Ext. 245.





GPWS ACTIVE
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Phase-Discriminating Capacitive Sensor System

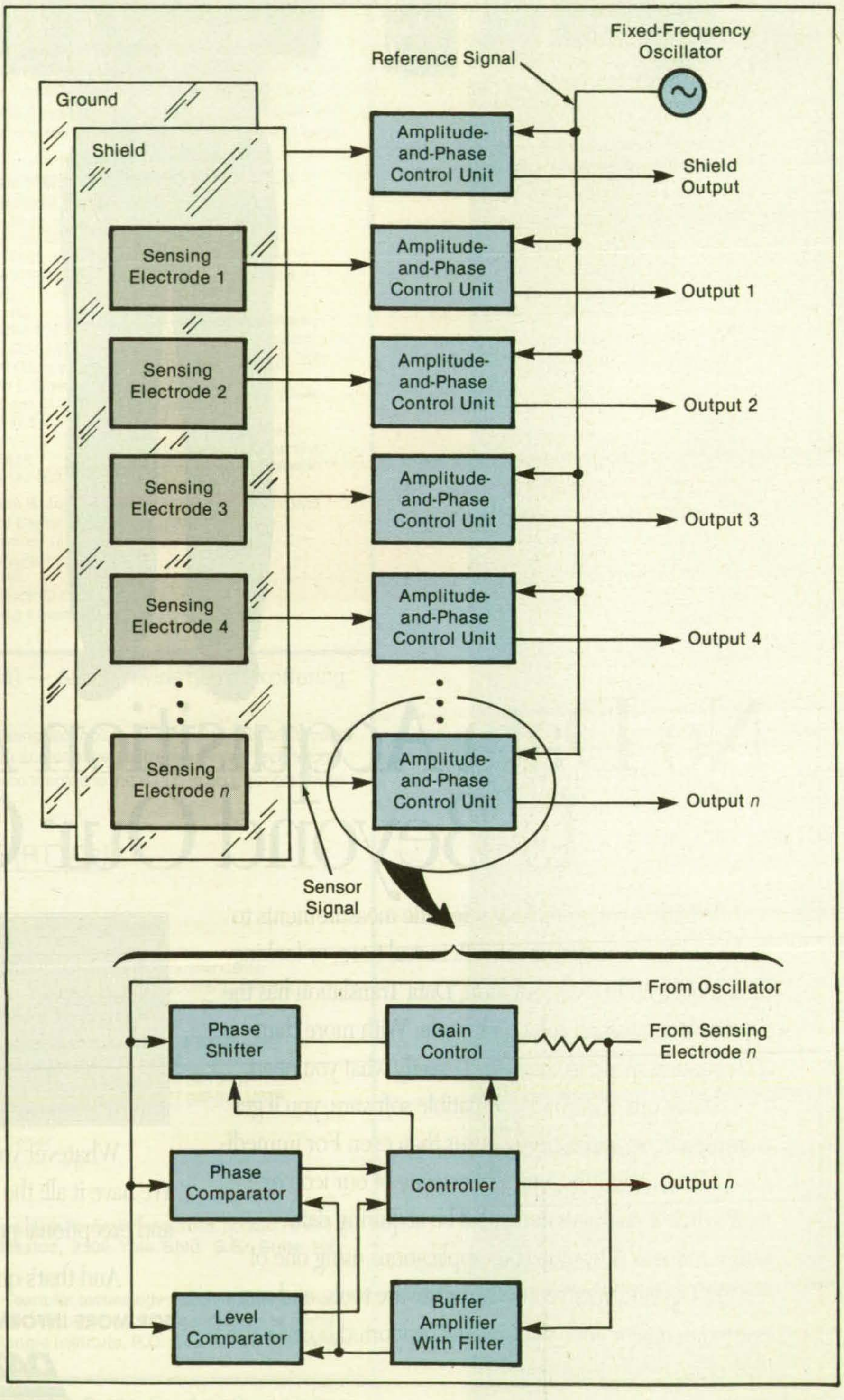
Sensors can be placed close together, enabling imaging of a sort.

Goddard Space Flight Center, Greenbelt, Maryland

The figure illustrates a capacitive proximity-sensor system that operates at a fixed frequency and incorporates feedback control subsystems that generate the outputs (proximity signals) from the various sensing electrodes. This system offers several advantages over older capacitive sensor systems, in which the proximity-induced changes in capacitances of the sensing electrodes cause changes in the frequencies of freely running oscillators connected to the electrodes. To prevent crosstalk among the older sensors (in which they affect or even lock onto each other's signals), it is necessary to place them far apart, thereby limiting the available spatial resolution. To accommodate the full range of variation in frequency, the input bandwidth of a sensor of the older type must be made relatively large, thereby limiting the signal-to-noise ratio and, therefore, the sensitivity and range of the sensor. Also, the freely running oscillators in the older sensors are subject to frequency drifts, caused principally by changes in temperature: these drifts can be mistaken for indications of proximity.

In this fixed-frequency system, all of the sensing electrodes in a multiple-electrode array, plus a driven capacitive shield (if used), are driven at the same fixed frequency from a stabilized crystal-controlled reference oscillator. The shield and each sensing electrode are connected to a phase-and-amplitude control unit, which is one of the feedback control subsystems mentioned above. The output signal from each control unit is a control voltage indicative of the control effort needed to maintain the voltage on the shield or sensing electrode at the same amplitude, phase, and frequency as those of the reference oscillator; a change in this signal is indicative of the change in capacitance of the sensing electrode and, therefore, of the proximity of an object.

In each control unit, the reference signal from the oscillator is passed through a conventional phase shifter and then through a conventional gain-control circuit. The output of the gain-control circuit drives a resistor connected to the associated sensing electrode and to a conventional buffer amplifier with narrow-band-pass filter. This filter can remove a significant amount of noise be-



Crosstalk Is Eliminated by maintaining the voltages on all the electrodes at the same amplitude, phase, and frequency. Each output is a feedback-derived control voltage, a change of which indicates the proximity-induced change in capacitance of the associated sensing electrode.

cause its bandwidth can be as small (e.g., a few hertz) as the anticipated characteristic frequency of motion of the objects to be sensed.

The reference signal from the oscillator and the output of the buffer amplifier with filter drive conventional phase and level comparators. The outputs of the comparators are fed to a controller, which drives the phase shifter and the gain-control circuit to keep the voltage on the sensing electrode at constant amplitude and phase at the reference frequency, and which puts out the voltage indicative of the control effort and proximity of an object. Furthermore, the rate of change of this voltage is indicative of the speed at which the object moves toward or away from the sensing electrode.

By locking the signals on all the electrodes to the same reference signal, one eliminates crosstalk. Therefore, sensing electrodes can be placed as closely together as desired. For example, many sensors packed together in a two-dimensional array can provide data from which one can construct a crude proximity image, with a picture element centered on each electrode. The edges of an object in such an image can be detected via an abrupt transition, between neighboring picture elements, of the output voltages from the corresponding sensing electrodes. The images and/or output voltages could be used, for example, to guide robots in proximity to various objects.

This work was done by John M. Vranish and Wadi Rahim of **Goddard Space Flight Center**. *For further information,* ***write in 6*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquires concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center [see page 22]. Refer to GSC-13460.

More About Detecting Sensor Failures in a Turbofan Engine

The performance of the ADIA algorithm has been demonstrated on a full-scale engine.

Lewis Research Center, Cleveland, Ohio

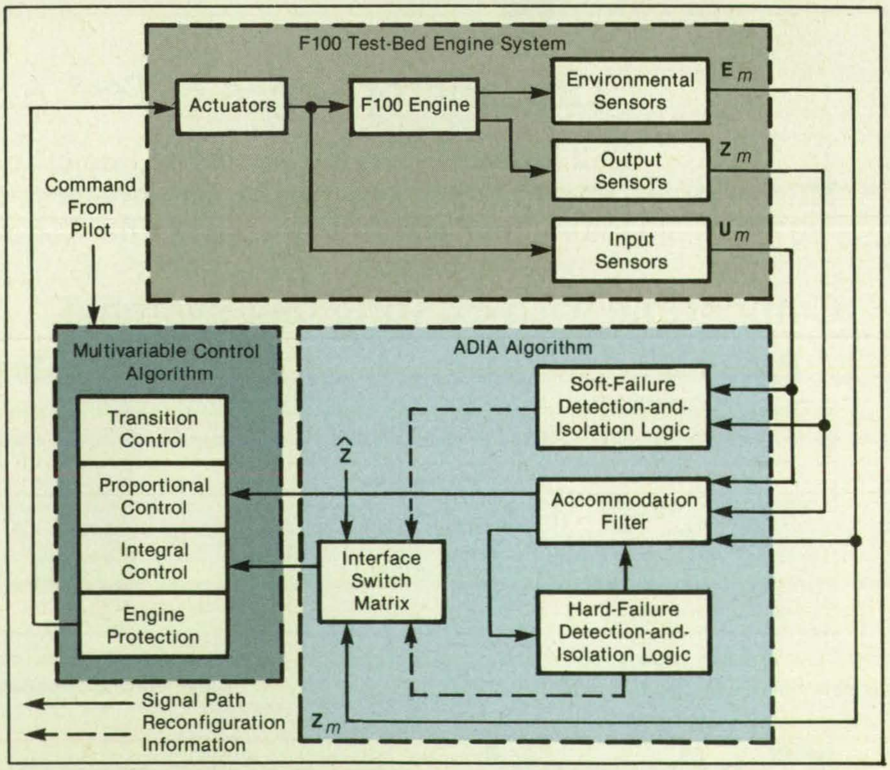
The Advanced Detection, Isolation, and Accommodation (ADIA) algorithm helps the digital electronic multivariable-control system of an advanced turbofan engine cope with failures of sensors in real time. Some aspects of previous versions of the ADIA algorithm, of the sensors, and of the control system, into which the algorithm is to be integrated, have been described in several previous articles in *NASA Tech Briefs*. The most recent version of the algorithm has been implemented in high-level software with parallel processing on a microcomputer and shown to perform very well in a demonstration on a full-scale F100 turbofan engine.

Accurate sensory data are essential for the correct operation of the control system, and studies have shown that sensors are among the least reliable components of the system. Therefore, redundancy of sensors is necessary for reliable control. The ADIA algorithm provides analytical redundancy: it includes a mathematical model that generates the redundant information that can be compared to measurements to detect failures. In comparison with hardware redundancy (the addition of more sensors and associated equipment), analytical redundancy adds less cost and weight.

The figure schematically illustrates the relationships among selected hardware and software components of the engine and control system. The multivariable-control algorithm is of the model-following, proportional-plus-integral type, with engine-protection logic that limits the sizes of command inputs to the engine. The ADIA algorithm incorporates advanced filtering and logic that detects sensor failures of two types: hard and soft. Hard failures are defined as out-of-range or large bias errors that occur instantaneously in the sensed values. Soft failures are defined as small bias errors or drift errors that increase relatively slowly with time.

The ADIA algorithm includes four major elements: (1) the hard-sensor-failure detection-and-isolation logic, (2) the soft-sensor-failure detection-and-isolation logic, (3) the accommodation filter, and (4) the interface switch matrix. In the normal mode of operation, the accommodation filter uses the full set of engine measurements to generate a set of optimal estimates of the measurements. These estimates [$\hat{\mathbf{Z}}(t)$, where t = time] are used by the control algorithm.

When the detection logic determines that a sensor has failed, the isolation logic then determines which sensor is faulty. This information is passed to the accommodation filter, which then removes the faulty measurement from further consideration. However, the accommodation filter continues to generate the full set of optimal estimates for use by the



The **ADIA Algorithm** is implemented along with the multivariable-control algorithm in mostly-FORTRAN software on several microprocessors that operate in parallel.

control algorithm. Thus, the control mode does not have to be restructured to correct for the failure of any sensor.

The inputs to the ADIA algorithm are the sensed engine-output variables, $\mathbf{Z}_m(t)$, the sensed engine-environmental variables, $\mathbf{E}_m(t)$, and the sensed engine-input variables, $\mathbf{U}_m(t)$. The estimates, $\hat{\mathbf{Z}}(t)$, of the engine outputs computed by the ADIA algorithm are used as inputs to the proportional part of the control algorithm. During operation in the normal mode, the measurements $\mathbf{Z}_m(t)$ are used in the integral part of the control algorithm to ensure accurate steady-state operation. The failure of a sensor is accommodated by reconfiguring the interface switch matrix to replace the measurement in the integral part of the control algorithm with the corresponding estimate produced by the accommodation filter.

This work was done by John C. DeLaat and Walter C. Merrill of **Lewis Research Center**. *Further information may be found in NASA TM-102327 [N89-29032], "A Real Time Microcomputer Implementation of Sensor Failure Detection for Turbofan Engines."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.

LEW-15381

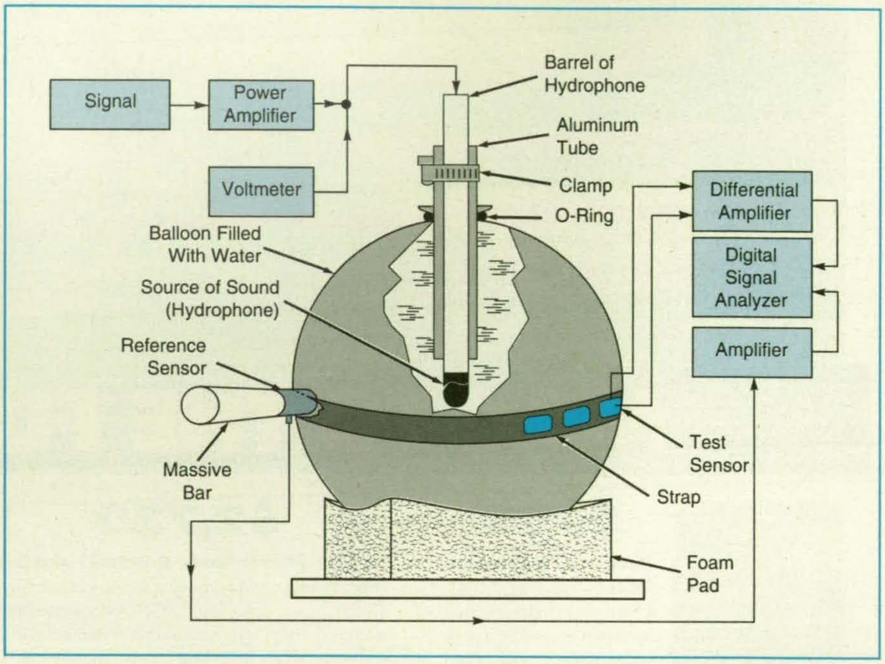
Improved Calibration of Acoustic Plethysmographic Sensors

Sensors are calibrated under conditions that resemble those in use.

Langley Research Center, Hampton, Virginia

An improved method of calibration of acoustic plethysmographic sensors involves acoustic-impedance test conditions like those encountered in use. Thus, unlike in older methods (in which test conditions are often unrealistic), the calibration is more likely to remain valid when the sensors are used. Such sensors are used to measure blood flow, blood pressure, heart rate, breathing sounds, and other vital signs from the surfaces of human bodies. They are attached to the torsos or limbs by straps or by adhesives.

In calibration methods in general, the pressure sensitivity and frequency response of a test sensor (the one to be calibrated) are compared with those of a reference sensor that has known characteristics. In the improved calibration method, the test sensor is installed much as it would be in service, and without immersing the sensor in water or any other liquid that might harm it. The sensor is attached to the outside of a water-filled balloon by use of a strap or adhesive. The reference sensor is also mounted on the balloon, along with a massive bar to present a high acoustic impedance to the incident sound. Water is chosen as the acoustic coupling medium in the balloon because its acoustic impedance approximates that of human tissue.



A Clamped Aluminum Tube holds a source of sound (a hydrophone) inside the balloon. The test and reference sensors are attached to the outside of the balloon. The diameter of the balloon is typically 0.3 to 0.4 m.

Inside the balloon, a hydrophone emits sound at frequencies below 30 kHz equally in all directions. Thus, the test sensor and the reference sensor receive sound of equal intensity. The balloon rests on a foam pad, which isolates the balloon somewhat from outside vibrations.

A signal generator and power amplifier excite the hydrophone with a single-frequency continuous wave. A voltmeter indicates the level of excitation.

The output of the test sensor is amplified and measured by a digital signal analyzer. The amplifier can be differential or single-ended, depending on the sensor. The reference sensor is usually single-ended and feeds a single-ended amplifier, the output of which is also measured by the digital signal analyzer.

In a test, the output voltages of the test and reference sensors are measured at various frequencies. The sensitivity of the test sensor at each frequency is computed as the output voltage of the test sensor divided by the gain of its amplifier divided by the sound pressure derived from the known response of the reference sensor. The procedure is repeated at a variety of frequencies to determine the frequency response of the sensor.

The hydrophone generates electromagnetic interference (EMI) as well as an acoustic signal. This EMI can affect the test and/or reference sensor if either contains a piezoelectric or other transducer that has a high electrical impedance. Therefore, the balloon and/or the sensors should be wrapped with grounded metal foil to suppress the EMI.

This work was done by Allan J. Zuckerwar and David C. Davis of **Langley Research Center**. *For further information,* ***write in 30*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 22]. Refer to LAR-14977.

MODEL #	FEATURES	APPLICATIONS
GP-KS152	■ Digital Signal Processing (DSP) ■ 1/2" Microlens CCD color microcamera ■ Electronic Light Control (ELC) ■ Minimum illumination 0.5fc ■ On-screen programmable features ■ 25 zone backlight compensation ■ Remote camera head 2/3" D x 1-1/2" L (without lens)	■ Endoscopic vision ■ Inspection ■ Nondestructive analysis ■ Laparoscopic vision
GP-KS202	■ 1/3" CCD color microcamera ■ 330 lines horizontal resolution ■ Auto tracing white balance ■ Remote camera head 1/2" D x 1-3/8" L (without lens)	■ Inspection ■ Nondestructive analysis ■ Machine vision ■ Endoscopic vision ■ Laparoscopic vision
GP-KS102	■ 1/2" CCD color microcamera ■ 430 lines horizontal resolution ■ Detachable head ■ Y/C (SVHS) and composite outputs ■ Auto gain control ■ Selectable TTL auto tracing ■ 12V DC operation ■ Camera head 2/3" D x 1-7/16" L (w/o lens)	■ Engines & machinery ■ Endoscopic vision ■ Nondestructive analysis ■ Surface mount inspection ■ Inspection ■ Laparoscopic vision
GP-MS112	■ 1/2" CCD B/W microcamera ■ 500 lines horizontal resolution ■ Detachable head ■ 12V DC operation ■ Camera head 2/3" D x 1-7/16" L (w/o lens)	■ Robotics ■ Machine vision ■ Inspection ■ Nondestructive analysis
GP-KR212	■ Digital Signal Processing (DSP) ■ 1/2" Microlens CCD color camera ■ 430 lines horizontal resolution ■ Minimum illumination 0.3fc at f1.4 ■ ELC and auto backlight comp. ■ 2H enhancer, aperture correction & knee circuitry	■ Microscopy ■ Measurement & inspection ■ Robotics ■ Surface mount inspection
GP-KR412	■ Same as GP-KR212 in addition to: ■ Full on-screen programming ■ 25 zone auto backlight comp. ■ Genlock capability	■ Microscopy ■ Measurement & inspection ■ Robotics
GP-KR402	■ 1/2" CCD color camera ■ 430 lines horizontal resolution ■ Variable speed electronic shutter ■ Y/C (SVHS) & composite outputs ■ 12V DC operation	■ Test & measurement ■ Inspection ■ Motion analysis
GP-MF552	■ Asynchronous electronic shutter ■ 2/3" CCD, 768 (H) x 495 (V) pixels ■ 570 lines horizontal resolution ■ Minimum illumination 0.05fc at f1.4 ■ External sync HD, VD	■ High speed analysis ■ Image processing ■ Process measurement
GP-MF502	■ 2/3" CCD, 768 (H) x 495 (V) pixels ■ 570 lines horizontal resolution ■ External sync HD, VD	■ Image processing ■ Process measurement
GP-MF702/D	■ 2/3" MOS image sensor 649 (H) x 491 (V) pixels ■ Asynchronous VD reset ■ Sq. pixels 13.5mm x 13.5mm with pixel clock in/out ■ Selectable scanning system (525 full line non-interlace) ■ Double speed scanning	■ Robotics ■ Inspection ■ Machine vision ■ High speed analysis
GP-MF200	■ 2/3" CCD, 768 (H) x 493 (V) pixels ■ 570 lines horizontal resolution ■ Remote head ■ External sync HD, VD	■ Factory automation ■ Robotics ■ Machine vision ■ Inspection

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Cameras shown with optional lenses.

Autonomous Deicing System for Airplane Wing

A "smart" electromechanical system detects ice and knocks it off.

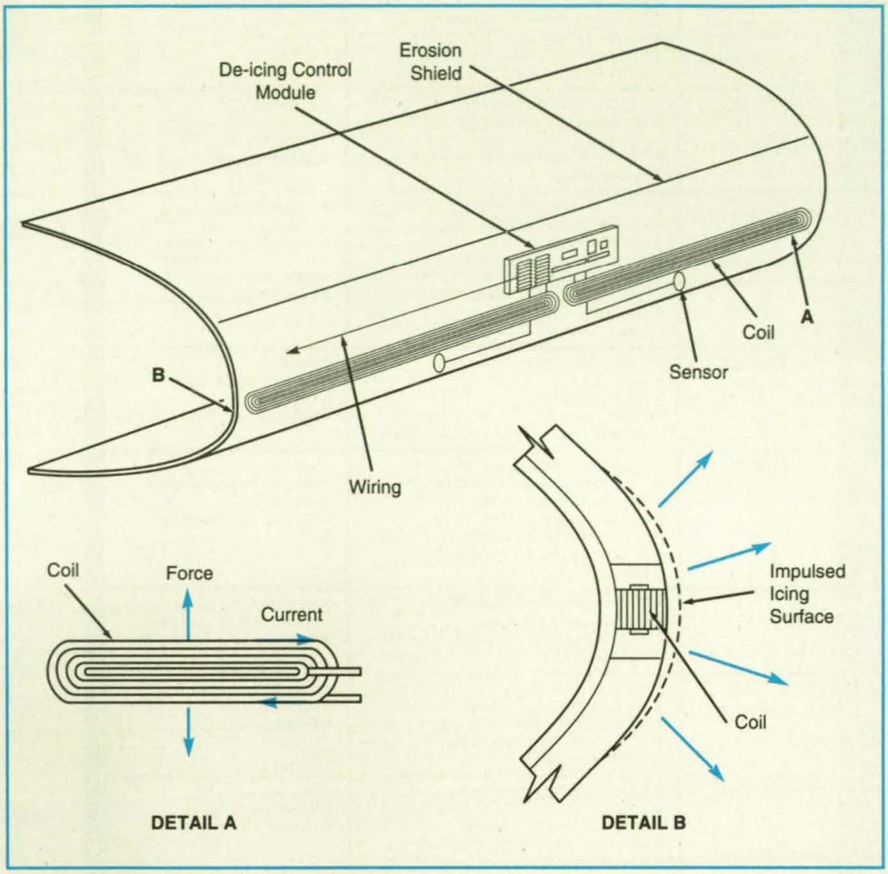
Lewis Research Center, Cleveland, Ohio

A prototype autonomous deicing system for an airplane includes a network of electronic and electromechanical modules at various locations in the wings and connected to a central data-processing unit. The system detects ice and excites vibrations of the skin to knock the ice off. (Ice decreases lift and increases drag and weight, and may lead to a crash if not removed before it accretes to a critical thickness.)

The system includes actuator coils, strain sensors, a microprocessor, and other microelectronic circuits integrated into modules mounted inside the wings. A dc-to-dc converter charges a bank of capacitors in each module. When the microprocessor triggers a silicon controlled rectifier, a pulse of current is discharged into one of the coils, giving rise to currents in opposite directions along the length of the coil; the interaction between the currents results in an impulsive mechanical excitation on the skin along the length of the coil.

The module performs two operations: measurement and deicing. During measurement, relatively small excitations are applied to selected coils, and the resulting small vibrations are monitored by the strain sensors. The sensor readings are fed to the central processor, which is programmed to recognize patterns of vibrations that signify various thicknesses and distributions of ice. In an extension of this concept, the outputs of the vibration sensors and other sensors might also be used to detect rivet-line fractures, fatigue cracks, and other potentially dangerous defects.

When the central processor determines that the ice at a given location is thicker than allowable, the module at that location is commanded to perform the deicing operation, in which a much larger excitation is applied to the coils. The resulting larger mechanical impulse knocks the ice off that spot. The system monitors the thickness of ice continually, performing the deicing operation only when and where necessary.



Each **Deicing Module** is a small, integrated solid-state device that, using long coils installed under the leading edge, excites small vibrations to detect ice and larger vibrations to knock ice off.

This work was done by G. A. Hickman and J. J. Gerardi of Innovative Dynamics for **Lewis Research Center**. *For further information,* ***write in 36*** *on the TSP Request Card.*
LEW-15376

Temperature-Compensating Inactive Strain Gauge

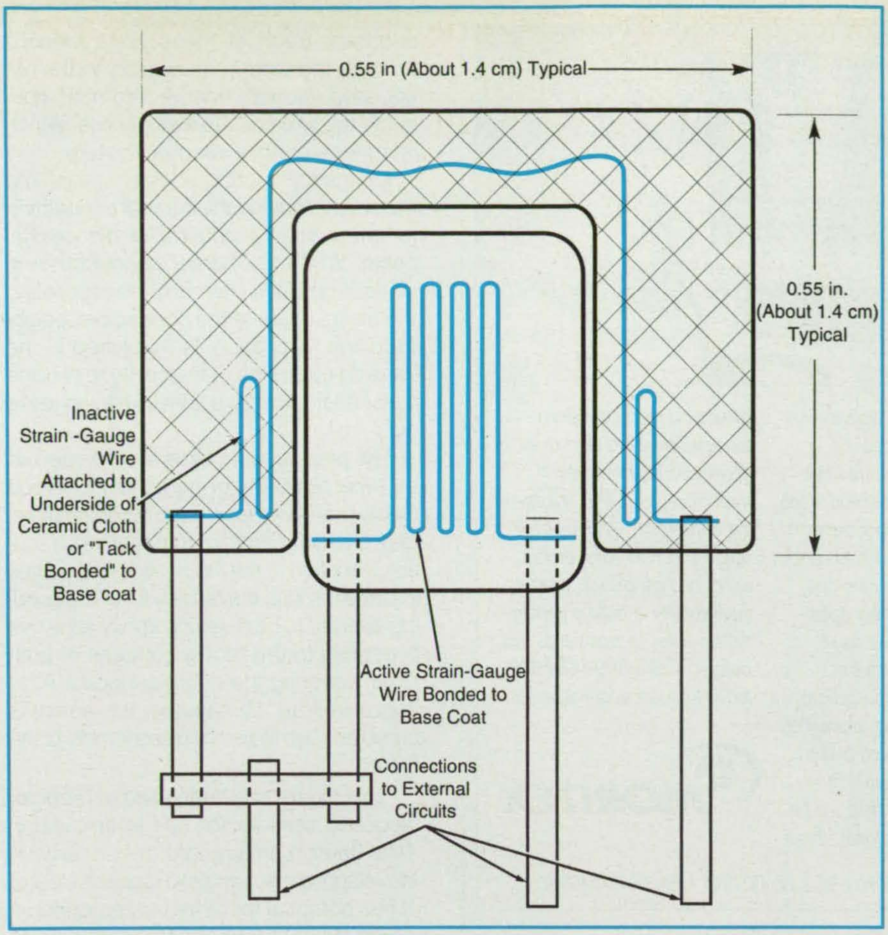
The thermal contribution to the output of the active gauge would be canceled.

Langley Research Center, Hampton, Virginia

High-temperature strain gauges of a proposed type would include both active gauge wires that would sense strains and inactive gauge wires that would provide compensation for the thermal contributions to the gauge readings. The inactive-gauge approach to temperature compensation is expected to be applicable to commercially available resistance-type strain gauges that can operate at temperatures up to 700 °F (about 370 °C) and to developmental strain gauges that will operate at temperatures up to 2,000 °F (about 1,090 °C). Temperature compensation is especially desirable in the higher temperature range because the thermal components of the outputs of strain gauges in that range are relatively large.

The figure shows a typical proposed high-temperature strain gauge. The active gauge wire would be bonded to the strain specimen via a ceramic base coat. The inactive gauge wire would be made of the same alloy as that of the active gauge wire and would be laid out around the active gauge wire; a piece of ceramic cloth cemented at its edges to the base coat would cover the inactive gauge wire and would hold the inactive gauge wire loosely in contact with, but not bonded to, the base coat. Thus, the strain from the specimen would be coupled into the active gauge wire but not into the inactive gauge wire.

The outer surface of the ceramic cloth would be impregnated with flame-



The **Inactive Strain Gauge** would be held in thermal contact with, but not bonded to, the strain specimen, while the active strain gauge would be bonded to the specimen. The inactive gauge would be laid out around three sides of the active gauge to minimize the effects of any residual gradients of temperature.

sprayed aluminum oxide or coated with a strain-gauge-type ceramic cement. This covering material would be similar or identical to that on the active gauge wire. Thus, the two gauge wires made of the same alloy would not only be in thermal contact with the strain specimen but would also be covered with nearly identical layers of thermal insulation and should therefore be at the same or nearly the same temperature at all times. Consequently, the thermal components of the contributions of the two gauge wires to the gauge readings should be equal or nearly equal.

The two gauge wires would be connected into adjacent arms of a wheatstone bridge, so that the identical thermal components of their outputs would cancel each other, leaving only the net strain component of output. This cancellation would occur at all operating temperatures, without need for calculation or additional compensating circuitry, and without need for precise measurement of the temperature of the active gauge wire.

This work was done by Thomas C. Moore, Sr., of **Langley Research Center**. *For further information,* ***write in 11*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquires concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 22]. Refer to LAR-14776.

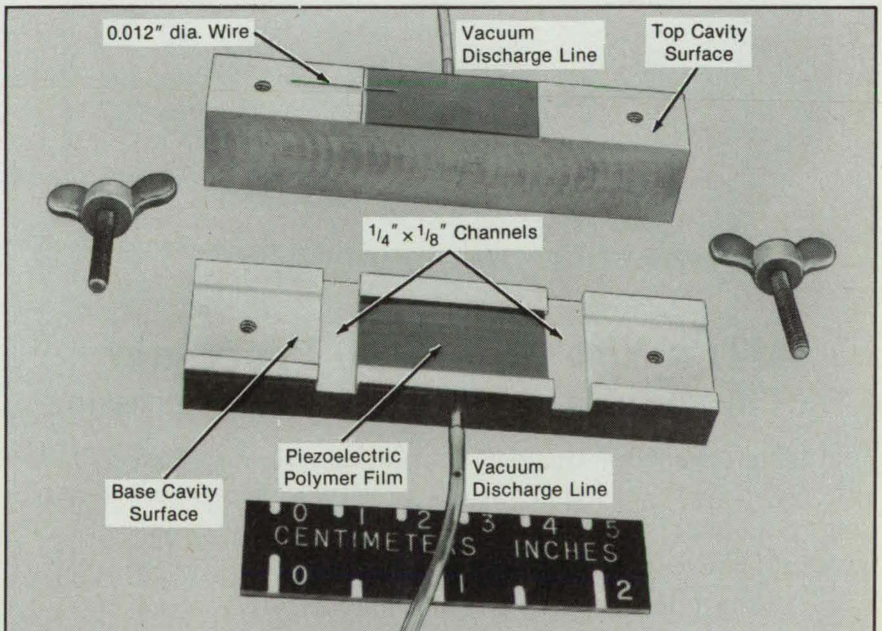
Holding Fixture for Making Piezoelectric Acoustic Sensors

The fixture has been used to fabricate sensors for fetal heart monitors.

Langley Research Center, Hampton, Virginia

To fabricate a piezoelectric acoustic sensor, it is necessary to form a suitable bond between two pieces of piezoelectric polymer film such as polyvinylidene fluoride (PVF_2). To meet this need, a novel vacuum holding device provides a quick and easy method of bonding together two strips of the thin film with a fast-setting epoxy adhesive. The fixture holds the films in place by vacuum while the adhesive is applied, it maintains a uniform bond line between the films, it provides an internal connection port between nickel coats on the films for the center conductor of a coaxial cable, and it eliminates the need to clean up excessive adhesive.

The fixture (see figure) includes a top section that mates with a base section. It also includes two wingnut screws and clear flexible plastic tubes that serve as vacuum lines. The mating surfaces are machined so that a cavity is formed when the top and base sections are mated together and held by the wingnut screws. Vacuum inlet ports are located in the middles of both the top and the base cavity



Polyvinylidene Fluoride Films Are Bonded together with epoxy while they are held in place by a partial vacuum.

surfaces. Each of these ports extends through the side of its section to the associated vacuum line. A Y-jumper connects the two lines to a single line, which is connected to a vacuum system.

On the top section, a wire extends into the cavity, making the internal connection for the center conductor of the coaxial cable. When the center conductor is in place, it provides internal contact between the nickel coats of the bonded piezoelectric films. A channel is machined in the base on each side of the cavity to provide a place for excessive adhesive to squeeze out.

The piezoelectric films are oriented so that the positively or negatively charged dipole moments face each other (positive-to-positive or negative-to-negative). Vacuum is applied to the fixture to hold the films in place through the remainder of the bonding operation. Fast-setting epoxy adhesive is applied to the facing surfaces of both films, covering the entire surfaces. After approximately 10 minutes, the epoxy is cured enough to permit disassembly of the fixture.

This fixture has been used to fabricate acoustic sensors for use in ambulatory fetal heart monitors that are undergoing development at Langley Reseach Center. It has potential for other heart-monitoring applications, as well as for other applications in which acoustic sensors can be used.

This work was done by E. Thomas Hall, Jr., of **Langley Research Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 22]. Refer to LAR-14240.

America's Best Inventions...Its Premier Researchers...Its Top Technology Managers... All Coming To Anaheim This December

TECHNOLOGY 2003

Dec. 7-9, 1993 • Anaheim Convention Center

Sponsored by NASA, NASA Tech Briefs, *and the Technology Utilization Foundation*

More than a conference, more than a trade show, Technology 2003 is a unique business resource that will put you in direct contact with the leading technology developers and tech transfer experts in U.S. federal laboratories, industry, and universities. Technology 2003 specifically can help you:

- Find ready-made solutions to engineering problems
- Discover ideas for new products and processes
- Learn how to successfully do business with the government
- Locate joint venture partners
- Broaden your knowledge and expertise

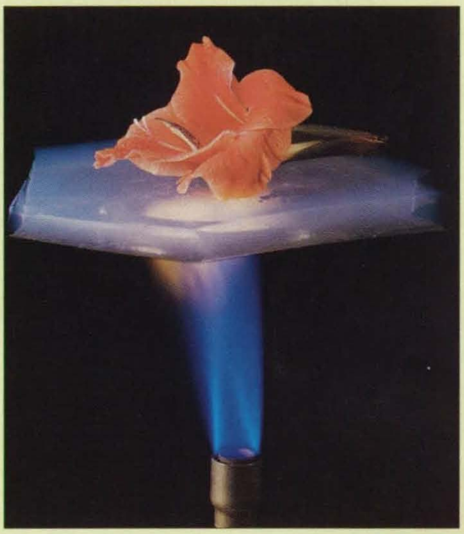
Technology 2003 is your key to unlocking the incredible wealth of "dual-use" technologies in the nation's 700+ federal labs. The three-day event will feature:

Exhibits A "who's-who" of govt. labs and high-tech companies will showcase their latest technologies and products available for license or sale in the 80,000 square-foot exhibits hall;

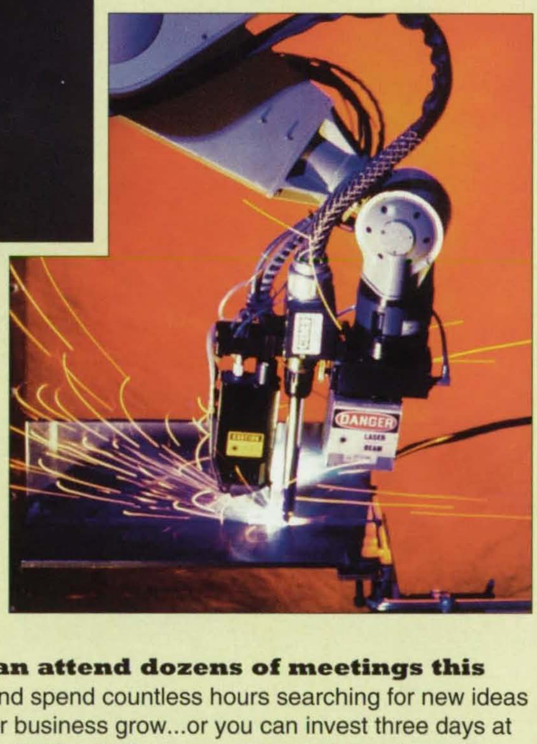
Symposia Over 100 symposia presentations — by top technologists from NASA, the departments of Defense, Energy, Agriculture, and Interior, and other key agencies and their contractors — will spotlight commercially-promising inventions and advanced processes in critical areas driving U.S. and world growth markets;

Plenary Session - Defense Conversion Find out how you can benefit from the government's multi-billion dollar effort to convert aerospace/defense technologies to new commercial markets, and how your company can take part in the Technology Reinvestment Project, a program of matching grants to explore commercial applications of government-funded R&D;

Workshops Information-packed workshops will include a primer on patent licensing and cooperative R&D agreements with federal labs; opportunities for international technology transfer and partnering; and a special session on new precision casting techniques for the U.S. foundry industry;



Awards Banquet The Fourth Annual Technology Transfer Awards Dinner, to be held December 8 at the Anaheim Marriott, offers an unparalleled opportunity to network with government and industry leaders. Seating is limited and expected to fill quickly, so reserve your tickets early.



Above: Lawrence Berkeley Lab will exhibit a unique transparent material called Silica Aerojel that features the best thermal insulating properties of any solid.

The Navy's Programmable Automated Welding System, subject of two Dec. 7 presentations, promises major improvements in manufacturing quality and productivity.

You can attend dozens of meetings this year and spend countless hours searching for new ideas to help your business grow...or you can invest three days at Technology 2003 and discover — in one place, at one time — the best technology America has to offer. Make a solid investment in your future: register today to attend Technology 2003 using the form on page H.

Technology 2003 *Program At A Glance*

	TUESDAY, DECEMBER 7	WEDNESDAY, DECEMBER 8	THURSDAY, DECEMBER 9
7:00 am	**Registration** *7:00 am - 5:00 pm*	**Registration** *7:00 am - 4:00 pm*	**Registration** *7:00 am - 2:00 pm*
8:30 am	**Plenary:** *Defense Conversion/Technology Reinvestment New Opportunities For Industry* *8:30 - 11:00 am*	**Workshop:** *How To Successfully Tap Into The Government's Technology Bank* *8:30 - 11:00 am*	**Concurrent Workshops:** *International Technology Transfer Forum* *Technology Alliance Opportunities In The Pacific Basin* *Precision Casting Technologies For The Next Century* *8:30 - 11:00 am*
9:00 am			**Exhibits Open** *9:00 am - 3:00 pm*
10:00 am	**Exhibits Open** *10:00 am - 6:00 pm*	**Exhibits Open** *10:00 am - 5:00 pm*	
1:00 pm	**Concurrent Symposia:** *Advanced Manufacturing* *Computer Hardware* *Environmental Technology* *Materials Science* *Photonics* *1:00 - 3:00 pm*	**Concurrent Symposia:** *Information Management* *Materials Science* *Power & Energy* *Robotics* *Virtual Reality/Simulation* *1:00 - 3:00 pm*	**Concurrent Symposia:** *Advanced Manufacturing* *Biotechnology/Medical Technology* *Environmental Technology* *Materials Science* *Video/Imaging Technology* *1:00 - 3:00 pm*
3:30 pm	**Concurrent Symposia:** *Artificial Intelligence* *Biotechnology* *Computer-Aided Design & Engineering* *Test & Measurement* *Video/Imaging* *3:30 - 5:30 pm*	**Concurrent Symposia:** *Advanced Manufacturing* *Artificial Intelligence* *Computer Software* *Environmental Technology* *Test & Measurement* *3:30 - 5:30 pm*	
	Technology Transfer Week Ceremonies & Reception *Exhibits Hall 6:00 - 7:30 pm*	*Technology Transfer Awards Dinner* *Marriott Hotel* *7:00 - 9:00 pm*	

National Technology Transfer Week

December 5 - 11, 1993

Working To Keep America Strong

This December in the Anaheim Convention Center, three events will converge with a single goal: to bolster the U.S. economy and industrial competitiveness by transferring leading-edge technologies to new commercial markets. In addition to Technology 2003, Technology Transfer Week will feature:

Technology Transfer Society Annual Meeting "How To Make Money In Technology Transfer" December 6-7

The T^2 Society, the leading society for individuals and firms engaged in technology transfer, will offer a dynamic forum featuring a "how to" approach to licensing and brokering, a review of winning mechanisms and hot technologies, and a look at the latest government thrusts, such as the Technology Reinvestment Project, and technical assistance networks. Call (317) 262-5022 for more information.

"Capitalizing Geographic Information Technology" December 8

Sponsored by the American Society for Photogrammetry & Remote Sensing, this one-day symposium will spotlight emerging business and financial opportunities in remote sensing, Geographic Information System (GIS), and Global Positioning System (GPS) technologies, and will vignette specific industry R&D efforts in these rapidly-growing, economically-critical areas. For more information call (505) 277-3622.

Your Technology 2003 symposia registration is your passport to all the events of Technology Transfer Week: complete and three-day symposia registrants may attend the sessions of these other conferences at no extra charge; one-day symposia registrants can attend sessions on the day(s) they are registered.

If your society or association is interested in holding a regional meeting as part of National Technology Transfer Week this year in Anaheim or next year in Washington, DC, contact Joseph Pramberger at (800) 944-NASA or (212) 490-3999.

Technology 2003 Exhibits:

Your One-Stop Shopping Place For Innovative Ideas

As you walk through the giant Technology 2003 exhibits hall, you'll see, touch, and test an amazing array of technologies, from electronics and computing devices to new materials and manufacturing techniques. Here's a partial list of the more than 250 federal laboratories, universities, and high-tech companies who will be demonstrating their latest inventions, products, and services:

- Aerospatiale
- Alberta Economic Development & Tourism
- Allied Signal Kansas City
- Altron Inc.
- American Inventors Corp.
- American Society for Photogrammetry & Remote Sensing
- Ames Research Center
- Arnold Engineering Development Center
- Austrian Trade Commission
- Ballistic Missile Defense Organization Technology Applications Program
- BF Goodrich Aerospace
- Brookhaven National Laboratory
- Bulova Technologies Inc.
- California Manufacturing Technology Center
- Canon Communications Inc.
- Catalyst Advertising/*International Invention Register*
- Center for Optics Manufacturing
- Centro Estero
- Coastal Systems Station
- Corning Inc.
- CorpTech
- COSMIC
- Cybernet Systems Corp.
- Datatape Inc.
- Diamonex Inc.
- Earth Data Analysis Center
- *Earth Observation Magazine*
- Edgewood Research, Development, & Engineering Center
- Electromechanical Systems Inc.
- ESL Inc., a subsidiary of TRW
- Federal Aviation Administration
- Federal Highway Administration
- Federal Laboratory Consortium
- Geophysical Survey Systems Inc.
- Goddard Space Flight Center
- Great Lakes Composites Consortium
- HEMCO Corp.
- Hewlett-Packard Co.
- Hughes Microelectronics
- Hypertat Corp.
- Idaho National Engineering Laboratory
- IIT Research Institute
- IIT Research Institute, Manufacturing Technology Information Analysis Center
- Indiana University Office of Technology Transfer
- Infolytica Corp.
- Information Handling Services
- Inframetrics
- INPEX
- Irvine Sensors Corp.
- Jet Propulsion Laboratory
- JFW Industries
- Johnson Space Center
- Kennedy Space Center
- Knowledge Express Data Systems
- Lamptronix
- Langley Research Center
- Lawrence Berkeley Laboratory
- Lawrence Livermore National Laboratory
- Lewis Research Center
- Lockheed Missiles & Space Co.
- Machida Inc.
- Macsyma
- Marshall Space Flight Center
- Metro Utah Inc.
- MicroPatent
- Mid-Atlantic Technology Applications Center
- NASA
- NASA Center for AeroSpace Information
- NASA Far West Regional Technology Transfer Center
- NASA STI Program
- *NASA Tech Briefs*
- NASA Technology Transfer Network
- National Center for Research Resources
- National Center for Toxicological Research
- National Institute of Standards & Technology
- National Renewable Energy Laboratory
- National Technology Transfer Center
- Naval Research Laboratory
- NAWCWPNS, China Lake
- NERAC Inc.
- NeuralWare Inc.
- Neutrik USA
- *New Technology Week*
- Novecon Technologies
- Novespace
- Oak Ridge National Lab
- Olympus Corp.
- Pacific Coast Technologies
- Pacific Northwest Laboratory
- Princeton University Plasma Physics Laboratory
- Proto Manufacturing
- Racal-Dana Instruments Inc.
- RAMOT—University Authority for Applied Research & Industrial Development
- Research Systems Inc.
- Research Triangle Institute
- Resonetics Inc.
- Rexham Industrial
- R.G. Hansen & Associates
- Rockwell International
- Sandia National Laboratories
- Simmonds Precision
- Society for the Advancement of Material and Process Engineering (SAMPE)
- Society of Automotive Engineers
- Sonic Perceptions Inc.
- Sonoscan Inc.
- Spire Corp.
- State/Industry-University Cooperative Research Center
- Stennis Space Center
- TCAM Technologies
- *Technology Access Report*
- Technology Transfer Society
- Technology Utilization Foundation
- Tektronix
- Thiokol
- Tiodize Inc.
- United Technologies Corp.
- Universal Technology Corp.
- University of Dayton Research Institute
- University of Georgia
- University of Texas Health Science Center at San Antonio
- U.S. Air Force "AFSTAR" Display
- U.S. Air Force Armstrong Laboratory
- U.S. Air Force Manufacturing Technology Directorate (MANTECH)
- U.S. Army Aeromedical Research Laboratory
- U.S. Army Armament Research, Development, & Engineering Center
- U.S. Army Research Lab
- U.S. Dept. of Agriculture—Agricultural Research Service
- U.S. Dept. of Agriculture—CSRS Office of Agricultural Materials
- U.S. Dept. of Energy, Efficiency & Renewable Energy
- U.S. Dept. of Energy Small Business Innovation Research
- U.S. Dept. of Energy Technology Utilization Office
- U.S. Dept. of Energy/Triodyne Inc.
- U.S. Dept. of the Interior
- U.S. Environmental Protection Agency
- U.S. Naval Academy
- Veritec Inc.

Is your company missing from this list?
Call Evelyn Mars at (800) 944-NASA to find out how you can exhibit at Technology 2003

Technology 2003 Conference Program

Tuesday, December 7

Tues., 8:30 - 11:00 am

Plenary Session: Defense Conversion & Technology Reinvestment—New Opportunities for Industry

Invited speakers include:
***Albert Gore**, Vice President of the U.S.*
***Daniel Goldin**, Administrator, National Aeronautics & Space Administration (NASA)*
***Lee Buchanan**, Director, Defense Sciences Office, Advanced Research Projects Agency (ARPA)*

Tues., 1:00 - 3:00 pm

National Critical Technologies Concurrent Symposia

Five concurrent sessions will be held during two-hour time blocks Tues.-Thurs. Presentations will last 30 minutes, including a question and answer period. Symposia registrants may attend whole sessions (four presentations) or individual presentations from a number of different sessions. Meeting rooms will be situated in close proximity for easy movement during sessions. Room assignments will be listed in the final program distributed at the show.

Advanced Manufacturing Part 1

Eight-Degree-of-Freedom Force-Controlled Macro-Micro Robot
Dr. Neville Marzwell, Manager, Advanced Technology Programs, Jet Propulsion Lab; Yulun Wang and Amante Mangaser, Computer Motion Inc.

Cooperative Computer Vision for Flexible Advanced Robot Controllers
Dr. Neville Marzwell, Jet Propulsion Lab; Tom Peurach and Brian Mitchell, Cybernet Systems Corp.

PAWS: Control of Welding Through Software and Hardware
Thomas Doyle, Babcock & Wilcox, R&D Division

Optical and Ultrasonic Sensing of Gas Metal Arc Welding
H.B. Smartt, J.A. Johnson, N.M. Carlson, P.L. Taylor, A.D. Watkins, and E.D. Larsen, Idaho National Engineering Lab; A.V. Clark, Jr., S.R. Schaps, and C.M. Fortunko, National Institute of Standards & Technology

Computer Hardware

Spacecraft Onboard Information Extraction Computer (SOBIEC)
David Eisenman, Deputy Manager, Flight Command & Data Management Systems, Jet Propulsion Lab; Raphael Some, Technical Director-Computer Systems, Irvine Sensors Corp.; Dr. Stephen Colley, Chairman and Founder, nCUBE

Pen-Based Computers: Computers Without Keys
Cheryl Conklin, Systems Design Engineer, Analex Space Systems

"The Vertical" Ergonomic Keyboard
Stephen Albert and Jeffrey Spencer, Co-inventors, Ergonomic Interface Keyboard Systems

A Systems Approach to Computer-Based Technical Training
Gaylen Drapé, Project Manager, ENSCO

Environmental Technology Part 1

Seed Viability Detection Using Computerized False-Color Radiographic Image Enhancement
J.A. Vozzo, Research Plant Psychologist, U.S. Department of Agriculture; M. Marko, Research Psychologist, N.Y. State Department of Health

A Commercialized, Continuous Flow Fiber-Optic Sensor for Trichloroethylene and Haloforms
Mark Johnson, Senior Chemist, and James Wells, Sensor Program Manager, Purus Inc.

New Automated Bioassay for Detecting Aqueous Pollutants and Pharmaceuticals
David Noever, Research Scientist, Marshall Space Flight Center

A Modular Approach for Automated Sample Preparation and Chemical Analysis
Michael Clark, EG&G Idaho

Materials Science Part 1

Bench-Scale Synthesis of Nanoscale Materials
M.F. Buehler, D.W. Matson, J.C. Linehan, and J.G. Darab, Research Engineers/ Scientists, Pacific Northwest Lab

Synthesis and Characterization of Advanced Materials Using the Sol-gel Process
Dr. Josephine Covino, Head, Applied Mechanics Branch, Naval Air Warfare Center Weapons Division

Deposition of Tantalum Carbide Coatings on Graphite by Laser Interactions
Dr. James Veligdan, Reactor Systems Division, Brookhaven National Lab

Development of a Unique Polyurethane Primer/Topcoat
H.L. Novak, Scientist, USBI Co.

Photonics

Optical Processing/Scanning Defect Mapping for Semiconductor Device Fabrication
Bhushan Sopori, Senior Project Coordinator, National Renewable Energy Lab

Neutral Ion Sources in Precision Manufacturing
Steven Fawcett, Optical Fabrication Branch, Marshall Space Flight Center

High-Power Diode Lasers for Solid-State Laser Pumps
Kurt Linden, Director of Commercial Products and Services, Spire Corp.

Pulsed Diode Ring Laser Gyro Development
Joseph De Fato, Engineer, Naval Command, Control & Ocean Surveillance Center

Tues., 3:30 - 5:30 pm

National Critical Technologies Concurrent Symposia

Artificial Intelligence Part 1

Refining Fuzzy Logic Controllers with Machine Learning
Hamid Berenji, Senior Research Scientist, Sterling Software

Fuzzy Classifier System for Process Control
C.L. Karr and C. Phillips, U.S. Bureau of Mines

Fuzzy-Neural Control of an Aircraft Tracking Camera Platform
Dennis McGrath, Naval Air Warfare Center, Aircraft Division

H46 Rotor Blade Balance Using Artificial Neural Networks
Marco Tedeschi, Aerospace Engineer, Naval Air Warfare Center, Lakehurst Aircraft Division

For Fastest Registration Fax the Form on Page H to (612) 378-6502.

Biotechnology/Medical Technology Part 1

Microencapsulation of Anti-Tumor, Antibiotic, and Thrombolytic Drugs in Microgravity
Dennis Morrison, Senior Biotech Scientist, Johnson Space Center

Cubanes: Super Explosives and Potential Pharmaceuticals
A. Bashir-Hashemi, Research Chemist, Geo-Centers

Dual Use of Image-Based Tracking Techniques: Laser Eye Surgery and Low Vision Prosthesis
Richard Juday, Manager, Image-Based Tracking, Johnson Space Center

Medical Imaging Using Cooled Optically-Stimulated Luminescence
Steven Miller, Staff Scientist, Pacific Northwest Labs

Computer-Aided Design & Engineering

Common Modeling System for Digital Simulation
Captain Rick Painter, Simulation Research Engineer, U.S. Air Force Wright Lab

Analytical Design Package
Michael Gran, Aerospace Engineer, U.S. Air Force

Assembly Flow Simulation of a Radar Design
Wesley Rutherford and Peter Biggs, Allied Signal Aerospace

CONFIG: Integrated Engineering of Systems and Their Operation
Jane Malin, Research Psychologist, Johnson Space Center; Dan Ryan, Technical Staff, MITRE; Land Fleming, Computer Systems Analyst, Lockheed

Test & Measurement Part 1

Continuous Measurement of Aircraft Wing Icing
Stephen Yao, Senior Research Engineer, Axiomatics Corp.

An Acousto-Optic Tunable-Filter-Based Near-Infrared Spectrometer for Analysis of Gasolines and Diesel Fuels (Presentation Part 1)
Steve Westbrook, Group Leader, Belvoir Fuels and Lubricants Research Facility

Analysis of Middle Distillate Fuels By FTIR (Presentation Part 2)
Dr. George Fodor, Staff Scientist, Southwest Research Institute

Electromagnetic Probe Technique for Fluid Flow Measurements
G.D. Arndt, Chief, Electromagnetic Systems Branch, Johnson Space Center; J.R. Carl, Project Specialist, Lockheed Engineering and Science Company

Ultrasonic Real-Time Determination of Chromium Thickness During Plating of Tubes
Julius Frankel, Physicist, Augustino Abbate and Mark Doxbeck, Mechanical Engineers, Benet Labs

Video & Imaging Technology Part 1

A Multimedia Adult Literacy Package
Dr. Jerry Willis, Adult Literacy Tutor Project, University of Houston; James Villareal, Johnson Space Center

Mapping, Analysis, and Planning System
C. Ross Hinkle, Carlton Hall, and Mark Provancha, Bionetics Corp.; William Knott and Burton Summerfield, Kennedy Space Center

Remote Sensing for Urban Planning and Disaster Assessment
Bruce Davis, Chief Scientist, and Nicholas Schmidt, Scientist, Stennis Space Center

Remote Sensing and the MS High-Accuracy Reference Network
Mark Mick, Program Manager, and Stan Wooley, Project Manager, Stennis Center

Tues., 6:00 - 7:30 pm

Technology Transfer Week Ceremonies and Reception
Speaker: Peter Wilson, Governor, State of California (invited)
Wine and cheese reception open to all Technology 2003 registrants.

Wednesday, December 8

Wed., 8:30 - 11:00 am

Workshop: How to Successfully Tap Into the Government's Technology Bank
(Speakers TBA)

Wed., 1:00 - 3:00 pm

National Critical Technologies Concurrent Symposia

Information Management

High-Speed Data Search
James Driscoll, University of Central Florida, Department of Computer Science

Database Tomography: Applications to Technical Intelligence
Dr. Ronald Kostoff, Director of Technical Assessment, Office of Naval Research; Henry Eberhart, Weapons Planner, Naval Air Warfare Center

Automated Mainframe Data Collection in a Network Environment
David Gross, Computer Engineer, Analex Space Systems

Advanced Automatic Parts Identification (API) System
Donald Roxby, Space Systems Div., Rockwell International Corp.

Materials Science Part 2

High-Elongation Elastomers
Vicki Brady and Russ Reed, Physical Scientists, Department of Defense

Solventless, Curable, Fluid Oligomeric Systems
Gene Lefave, President, and Leo Stanton, Technical Operations, Fluid Polymers Inc.; James Foreman, Research Chemist, Martin Marietta Electronics, Information, & Missiles Group

Plasma Treatment of Polymer Dielectric Films to Improve Capacitive Energy Storage
A. Yializis, President, Sigma Labs; M. Binder, Army Research Lab

Development of Radiation-Resistant Cable Insulators
Dr. Bom Soon Lee, Metallurgist/Principal Investigator, Brookhaven National Lab

Power & Energy

Use of Magnetic Compression to Support Turbine Engine Rotor
Chris Pomfret, Project Engineer, Wright-Patterson Air Force Base

Low-Power CMOS Digital Cell Library
Robert Schober, Jet Propulsion Lab

Solar Absorption Cooling: Renewable Energy Technology for Protecting the Ozone Layer and Demand Side Management
Russell Hewett, Task Leader, National Renewable Energy Lab

Fiber-Optic Solar Simulator
Bhushan Sopori, Senior Project Coordinator, National Renewable Energy Lab

Robotics

Application of Dexterous Space Robotics Technology to Myoelectric Prostheses
Charles Price, Chief, Robotics Systems Technology Branch, and Cliff Hess, Lead Engineer, Dexterous Robotics, Johnson Space Center

U.S. Navy Omni-Directional Vehicle Development
Hillery McGowen, Physicist, Naval Surface Warfare Center

Applying Robotics to HAZMAT
Richard Welch, Task Manager, Jet Propulsion Lab

Advanced Teleoperation: Technology Innovations and Applications
Paul Schenker, Group Supervisor, and Antal Bejczy, Technical Manager, Jet Propulsion Lab

Virtual Reality/ Simulation

Anatomy Meets Virtual Reality: The Virtual Visual Environment Display
Laurie Sprague, LinCom; Mike Goza, Johnson Space Center

Low-Cost Virtual Reality Tool for Construction Equipment Design
Harry Frisch, Goddard Space Flight Center; Harry Yae, University of Iowa

High-Performance Real-Time Flight Simulator
Jeff Cleveland, Project Engineer, Langley Research Center

Application of Above Real-Time Training (ARTT) for Simulators: Acquiring High-Performance Skills
Dutch Guckenberger, Senior Software Design Engineer & Research Associate, ECC International Corp.

Wed., 3:30 - 5:30 pm

National Critical Technologies Concurrent Symposia

Advanced Manufacturing Part 2

Electron Beam/Optical Lithography Process for the Fabrication of Sub-Half-Micron-Gate-Length MIMIC Chips
James Sewell and Christopher Bozada, Electron Beam Lithography Team Leaders, Wright Patterson Air Force Base

Dry and Liquid Cold Fusion of Materials
Dr. Adrian Joseph, Research Director, Metafuse Corp.

Near-Net-Shape Manufacturing: Spray-Formed Metal Matrix Composites and Tooling
Kevin McHugh, Senior Scientist, and James Key, Techical Leader, Idaho National Engineering Lab

Hot Drape Forming of Composite Structural Shapes
R. Thomas Ott, Composites Engineer, Boeing Company

Artificial Intelligence Part 2

Advances in Neural Network Pattern Recognition
Dr. Harold Szu, Leader, Neural Network and Automation Group, Naval Surface Warfare Center

New Approaches for Real-Time Decision Support Systems
Dr. Charles Hair, RDT&E Division, Naval Command, Control, & Ocean Surveillance Center

Knowledge-Based Commodity Distribution Planning
Dr. Victor Saks and Ivan Johnson, Carnegie Group Inc.

Intelligent Hypertext System Provides Rapid, Effective Access to Information in Large Documents
Nathalie Mathe, Artificial Intelligence Research Branch, Ames Research Center

Computer Software

Automatic Translation Among Spoken Languages
Sharon Walter, Computer Engineer, Rome Laboratory

A PC Program to Optimize System Configuration for Desired Reliability at Minimum Cost
Steven Hills, Engineering Specialist, EG&G Idaho

Evolving Software Reengineering Technology for the Emerging Innovative-Competitive Era
Philip Hwang, Chief Scientist and Engineer, Naval Surface Warfare Center

A Library of Reusable Software Components with Automatic Parallelism
Michael Boucher, Principal Analyst, Dakota Scientific Software Inc.

Environmental Technology Part 2

Photovoltaic Power Without Batteries for Continuous Cathodic Protection
Wallace Muehl, Electrical/Mechanical Engineer, U.S. Navy

CFC Replacement Alternatives
H. Richard Ross, Group Leader, Sverdrup Technology Inc.

Supersonic Gas-Liquid Cleaning Systems
Raoul Caimi and Eric Thaxton, Kennedy Space Center

Regenerating Used Aqueous Cleaners with Ozone and Electrolysis
Mike McGinness, President, Custom Process Systems and Service Co.

Test & Measurement Part 2

Microwave Sensor for Ice Detection
G.D. Arndt and A. Chu, Johnson Space Center; L.G. Stolarczyk, RimTech/Stolar

A Versatile Nondestructive Evaluation Imaging Workstation
E. James Chern, Goddard Space Flight Center; David W. Butler, Paramax Systems Corp.

A New High-Speed IR Camera System
Jeffrey Travis, Head, Detector Systems Section, Goddard Space Flight Center

Universal Signal Conditioning Amplifier
Jim Cecil, Electronics Engineer, Kennedy Space Center

Preregister by November 19 and SAVE up to 30%

Wed., 7:00 - 9:00 pm

The Fourth Annual Technology Transfer Awards Dinner

Guest speaker: James Clark, Chairman and Founder, Silicon Graphics Corp. (invited)

Thursday, December 9

Thurs., 8:30 - 11:00 am

Concurrent Workshops:

International Technology Transfer Forum
Top-level speakers from Russia, Canada, France, Italy, Austria, and other nations will introduce their portfolio of leading-edge technologies for transfer and provide key contacts and resources for follow-up.

Technology Alliance Opportunities in the Pacific Basin
Discover specific opportunities for cooperative R&D and technology transfer with leading companies, universities, and government organizations in Pacific Rim countries.

Precision Casting Technologies for the Next Century
Recent developments in applying sophisticated computer techniques to designing the casting process have shown that significant improvements can be attained in cost, quality, and time-to-market. Experts from the U.S. foundry, aerospace, and automotive industries as well as academia and NASA will discuss recent advances in these computer technologies.

Thurs., 1:00 - 3:00 pm

National Critical Technologies Concurrent Symposia

Advanced Manufacturing Part 3

Precision and Manufacturing at Lawrence Livermore National Lab
Theodore Saito, Acting Leader, Precision Engineering Program, Lawrence Livermore National Lab

Potential Capabilities of Reynolds Stress Turbulence Model in the COMMIX-RSM Code
F.C. Chang and M. Bottoni, Materials and Components Technology Division, Argonne National Lab

An Improved Plating Process
John Askew, Chief, Process Engineering Branch, Benet Labs

The Unlimited Applications of Microtubes
Dr. Wesley Hoffman, Carbon Materials Research Group Leader, Phillips Lab

Biotechnology/Medical Technology Part 2

Composite Redesign of Obstetrical Forceps
Stan Smeltzer and Seth Lawson, Engineers, Marshall Space Flight Center

The NASA/Baylor Left Ventricle Assist Device (LVAD)
Greg Aber, Propulsion Test Engineer, Johnson Space Center

A Fuzzy Logic Controller for Hormone Administration Using an Implantable Pump
Dr. L. Stephen Cole, Group Chief Technologist, and George Wells, Jr., Jet Propulsion Lab

Monitor for "Status Epilepticus" Seizures
Mark Johnson and Dr. Thomas Simkins, Benet Labs

Environmental Technology Part 3

Gas Stream Purifier
Steven Adam, Lead Engineer/Scientist, McDonnell Douglas

Using Spacecraft Trace Contaminant Control Systems to Cure Sick Building Syndrome
John Graf, Johnson Space Center

A New Material for Removing Heavy Metals from Waste Water
Warren Philipp, Senior Research Chemist, and Kenneth Street, Chief, Chemical Sampling and Analysis Branch, Lewis Research Center; Joseph Savino, Technology Transfer Facilitator, Cleveland State University

Dewatering of Contaminated River Sediments
Ronald Church and Carl Smith, Mining Engineers, U.S. Bureau of Mines

Materials Science Part 3

Advances in Carbon-Carbon Materials
Howard Maahs, Head, Applied Materials Branch, Langley Research Center

Casting of Weldable Graphite-Magnesium Composites with Built-In Metallic Inserts
Jonathan Lee, Marshall Space Flight Center

Design and Analysis of Composite Isogrid for Bridge Construction
James Koury, Phillips Lab; Piyush Dutta, Army Cold Regions Research and Engineering Lab; Richard Lampo, Army Construction Engineering Research Labs

Improved Construction Materials for Polar Regions Using Microcellular Thermoplastic Foams
Daniel Cunningham, Axiomatics Corp.

Video and Imaging Technology Part 2

Visually Optimized DCT Image Compression
Albert Ahumada and Andrew Watson, Research Scientists, Ames Research Center

Voice and Video Transmission Experiment Using XTP and FDDI
John Drummond, Edwin Cheng, and Will Gex, Naval Command, Control, & Ocean Surveillance Center

An Intelligent Interactive Visual Database Management System for Space Shuttle Closeout Image Management
Dr. James Ragusa, Associate Professor, University of Central Florida

The Trustworthy Digital Camera: Restoring Credibility to the Photographic Image
Gary Friedman, Technical Group Leader, Jet Propulsion Lab

Exhibit Hours

12/7	10:00 am - 6:00 pm
12/8	10:00 am - 5:00 pm
12/9	9:00 am - 3:00 pm

How To Register

Complete the registration form on the next page and mail with check or money order (if applicable) to the Technology Utilization Foundation (c/o Brede Registration), or fax it with credit card data to (612) 378-6502. Deadline for preregistration is Friday, November 19.

Preregister and $ave:

	by 11/19	on-site
Complete Registration (includes symposia and exhibits, a ticket to the Awards Dinner, and a set of Tech 2003 proceedings)	$250	$295
Three-Day Symposia/Exhibits	$150	$195
One-Day Symposia/Exhibits	$75	$95
Awards Dinner Only	$50	$60
Exhibits Only	— No Charge —	

Preregistrants will receive written confirmations via mail along with their name badges and imprinter cards. Badge holders, programs, and dinner tickets must be picked up in person at the Anaheim Convention Center (Hall C) during the following hours:

On-Site Registration Hours

Monday, Dec. 6	8:00 am - 5:00 pm
Tuesday, Dec. 7	7:00 am - 5:00 pm
Wednesday, Dec. 8	7:00 am - 4:00 pm
Thursday, Dec. 9	7:00 am - 2:00 pm

Special Hotel Rates

Anaheim Marriott (headquarters hotel) (800) 228-9290	$88 sgl/dbl
Quality Hotel & Conference Center (800) 231-6215	$49 sgl/dbl

Hotel space is limited, so book early! When making reservations, you must identify yourself as a participant in National Technology Transfer Week to receive the special rates. All reservations require a first night advance deposit.

Air Travel Savings & Prizes

United Airlines, official airline for Technology 2003, is offering a 10% discount off the unrestricted YUA coach fare or 5% off the lowest applicable fares. Attendees who book their tickets via UA's toll free number (1-800-521-4041) will have their names entered into a drawing for two round-trip tickets good in the continental U.S. and Hawaii. Refer to meeting ID# 537CB when reserving tickets.

Car Rental Discounts

Technology 2003 attendees are entitled to a special AVIS Rent-A-Car discount. Please call 1-800-331-1600 and refer to the Technology 2003 discount number: B711901. Discount is valid Nov. 30 - Dec. 16 and includes unlimited mileage.

Tickets To Disneyland

Disneyland is located minutes from the hotels and convention center. Discount tickets to Disneyland will be available for purchase in the Technology 2003 registration area during the days and hours listed above.

Questions? Call Wendy Janiel at (800) 944-NASA or (212) 490-3999.

TECHNOLOGY 2003 PREREGISTRATION FORM

USE A SEPARATE FORM OR PHOTOCOPY FOR EACH REGISTRANT. BE SURE TO ANSWER ALL QUESTIONS BELOW.

Name ______________________________

Title ______________________________

Company ______________________________

Address ______________________________

City/St/Zip ______________________________

Phone No. ______________________________

Which of the following best describes your industry or service?

(check one)

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B ☐ Computers
C ☐ Communications
D ☐ Transportation/Automotive
E ☐ Aerospace
F ☐ Defense
G ☐ Government
H ☐ Materials/Chemicals
I ☐ Industrial Equipment
J ☐ Manufacturing
K ☐ Power/Energy
L ☐ Biomedicine
M ☐ University
N ☐ Research Lab
O ☐ Other
specify______________

Which of these products do you recommend, specify, or authorize the purchase of?

(check all that apply)

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C ☐ Computers/Peripherals
D ☐ CAD/CAE/CAM/CASE
E ☐ Lasers/Optics
F ☐ Materials
G ☐ Mechanical Components
H ☐ Positioning Equip./Motion Control
I ☐ Test/Measurement Instruments
J ☐ Sensors/Transducers
K ☐ Data Acquisition
L ☐ Video/Imaging Equipment
M ☐ Industrial Controls/Systems
N ☐ Communications Equipment
O ☐ Laboratory Equipment

Your principal job function is: (check one)

A ☐ General & Corporate Management
B ☐ Design & Development Engineering
C ☐ Engineering Services - Tests/Quality
D ☐ Basic Research
E ☐ Manufacturing/Production
F ☐ Purchasing/Procurement
G ☐ Other
specify: ______________________________

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B ☐ Three-Day Symposia/Exhibits $150
C ☐ One-Day Symposia/Exhibits $75
check day: ☐ 12/7 ☐ 12/8 ☐ 12/9
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Registrations and Awards Dinner reservations are transferrable and may be cancelled until November 19, 1993. After that date no cancellations will be refunded.

Return with payment to: Technology Utilization Foundation c/o Brede Registration PO Box 18187, Minneapolis, MN 55418-0187

For fastest registration fax to: (612) 378-6502

Fast, Low-Power, Hysteretic Level-Detector Circuit

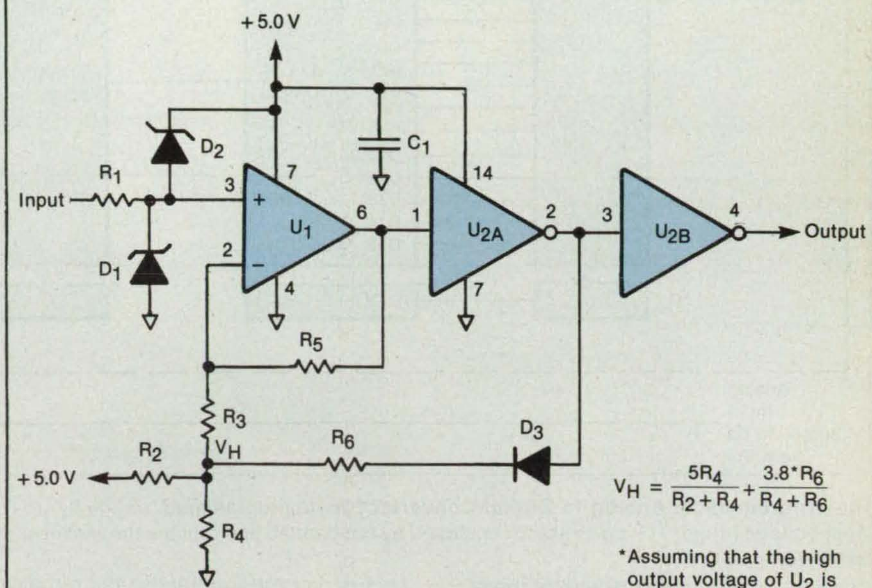
Required power is reduced from about 25 to about 1.25 mW.

Lewis Research Center, Cleveland, Ohio

A circuit for the detection of preset levels of voltage or current is intended to replace a standard fast voltage comparator. Level detectors are typically used to activate or deactivate other circuits (e.g., analog monitoring circuits) when the preset levels, called "trip points," are reached. The standard fast voltage comparator requires a typical supply potential and current of 5 Vdc and 5 to 10 mA, respectively, and standard voltage comparators that consume less power have been slow. The new circuit operates at almost the speed of the standard fast voltage comparator, yet requires only about 250 μA at 5 Vdc.

The circuit (see figure) comprises a low-power analog circuit and a complementary metal oxide/semiconductor (CMOS) digital circuit connected in an overall closed feedback loop to decrease rise and fall times, provide hysteresis, and provide trip-level control. The overall closed feedback loop contains multiple subloops that combine linear and digital feedback. The levels of sensed signals and the hysteresis level can easily be adjusted by selection of the components to suit the specific application.

This work was done by Mordechai Arditti of Rockwell International Corp. for **Lewis Research Center**. *No further documentation is available.*
LEW-14974



$$V_H = \frac{5R_4}{R_2+R_4} + \frac{3.8^*R_6}{R_4+R_6}$$

***Assuming that the high output voltage of U_2 is approximately 4.5 V.**

Typical Components

R_1 = 15 K	D_1 = 1N5711	U_1 = HA 5151
R_2 = 49.9 K	D_2 = 1N5711	U_2 = 74HCT14
R_3 = 10 K	D_3 = 1N4149	(Four Sections Not Used,
R_4 = 100 Ω	C_1 = 0.1 μF	Inputs Connected to Ground)
R_5 = 200 K		
R_6 = 22.1K		

This **Hysteretic Analog/Digital Level Detector** operates at unusually low power with little sacrifice of speed.

Programmable Analog-to-Digital Converter

Sizes of digital intervals can be changed during operation.

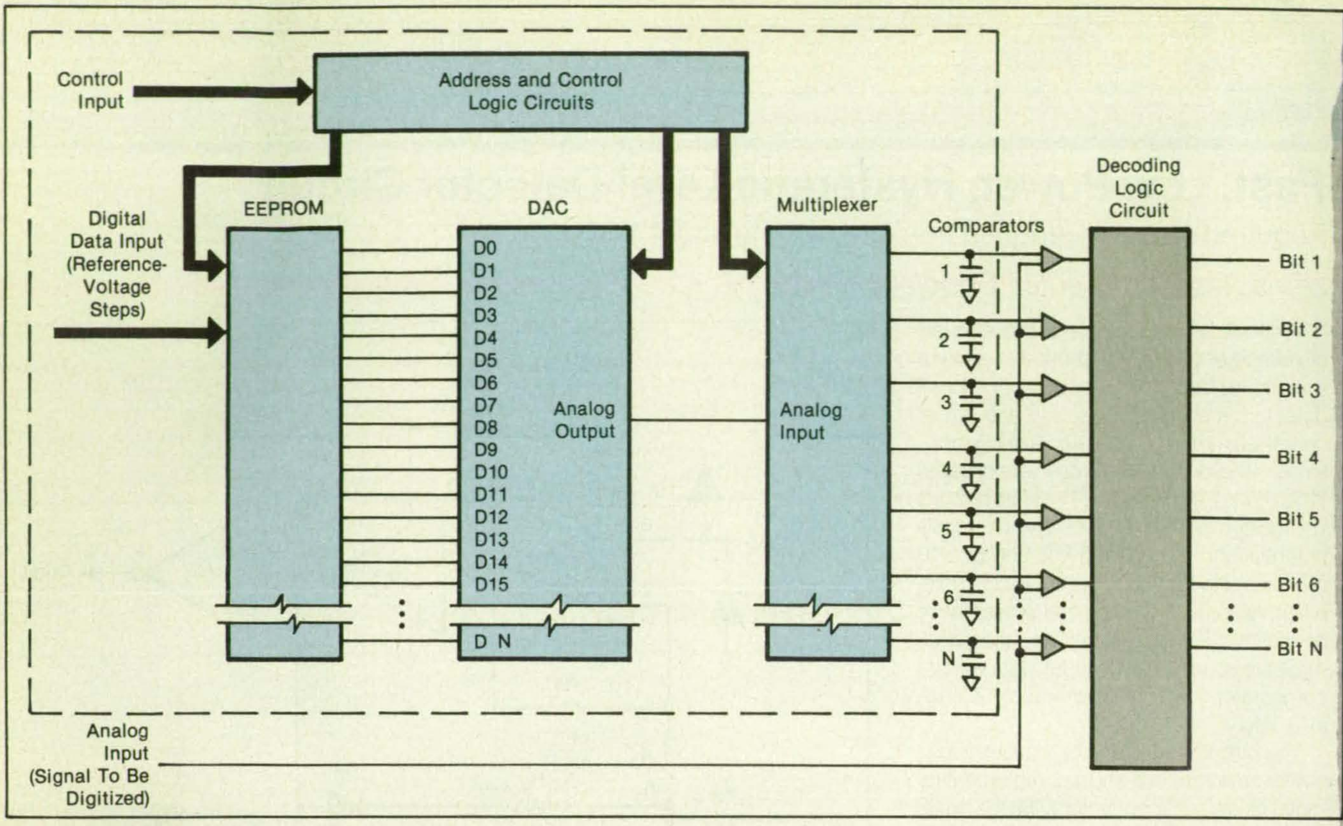
Langley Research Center, Hampton, Virginia

The circuit illustrated in the figure is a high-speed analog-to-digital converter with programmable voltage steps that can be changed during operation. The purpose of these programmable voltage steps is to allow concentration of the converter resolution over a specific portion of a waveform. This circuit would be particularly useful in digitizing wind-shear radar and lidar return signals, in digital oscilloscopes, and in other applications in which it may be desirable to increase the digital resolution over a specific area of a waveform while accepting lower resolution over the rest of the waveform. Thus, an effective increase in dynamic range can be achieved without an increase in the number of analog-to-digital converter bits. The advantage of using fewer bits is that it enables faster analog-to-digital conversion.

In a conventional analog-to-digital converter, a reference voltage is divided into N = 2^n (where *n* is an integer) equal intervals by use of a chain of resistors, and each resulting fixed reference-voltage step is fed to one of the inputs of a comparator dedicated to that step. The input voltage to be digitized is fed to the other input of each comparator. The first comparator (in ascending-voltage order) in which the reference-voltage step exceeds the input voltage produces a logic signal that determines the digital word that represents the input voltage.

This analog-to-digital converter differs from a conventional one in the manner in which the reference-voltage steps are generated. To generate the reference-voltage steps with variable intervals, the chain of resistors is replaced by a digital-to-analog converter (DAC), analog multiplexer, or electrically erasable programmable read-only memory (EEPROM) or an equivalent memory device, along with data, address, and control logic circuits. In addition, a capacitor, a charge-coupled-device charge well, or an other energy-storage device is connected to the reference voltage input terminal of each comparator.

The user can load, into the EEPROM, *N* digital words, each representing the



The **Programmable Analog-to-Digital Converter** can be programmed "on the fly" to concentrate its resolution on a small part of the input-voltage range. The parts shown enclosed by the dashed line replace the resistive voltage divider of a conventional analog-to-digital converter.

reference-voltage step for one of the *N* comparators. As each word is clocked out of the EEPROM and presented to the DAC, the DAC responds by producing the appropriate analog voltage. This analog voltage is steered by the analog multiplexer to the appropriate energy-storage device which retains the voltage as a usable reference for its associated comparator while the remainder of the storage devices are loaded with their reference values. These values are refreshed repeatedly during operation. The advantage of this design is that it enables the user to change the reference-voltage steps at will, making it possible to concentrate the resolution of the digitizer on one or more features of a waveform.

This work was done by Edward H. Kist, Jr., of **Langley Research Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 22]. Refer to LAR-14765.

Grounded Coplanar Waveguide Feeds Phased-Array Antenna

Components of an end-fire antenna have been built and tested.

Lewis Research Center, Cleveland, Ohio

A prototype electronically steerable K-band end-fire antenna includes a phased array of four printed-circuit linear dipole elements fed by a grounded coplanar waveguide (GCPW). The prototype antenna was built and tested to demonstrate the feasibility of large two-dimensional arrays made with grounded coplanar waveguides (see Figure 1).

The distribution-and-phasing network of the prototype antenna is fed through a single coaxial transmission line. The microwave signal entering the antenna is split equally by three GCPW T junctions onto four GCPW transmission lines (see Figure 2). The relative phases of the electromagnetic fields at the radiating elements are controlled by monolithic microwave integrated-circuit (MMIC) phase shifters, which are dc-isolated from the rest of the network by a pair of GCPW couplers. These couplers have been optimized to have a passband at the nominal operating frequency of 21 to 25 GHz. The GCPW transmission lines are tapered to provide a better match to the width of the microstrip lines on the MMIC's.

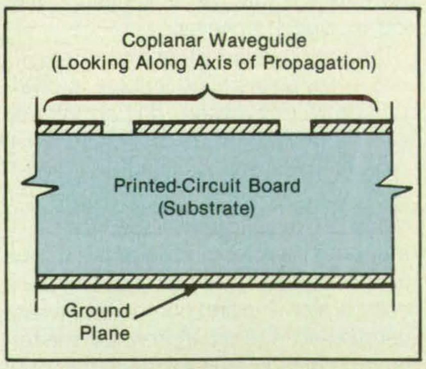


Figure 1. **Grounded Coplanar Waveguide** is a variant of coplanar waveguide that incorporates an additional ground plane on the back of the substrate.

The MMIC phase shifters are of the reflection type. Each includes a Lange coupler and two reverse-biased varactor diodes.

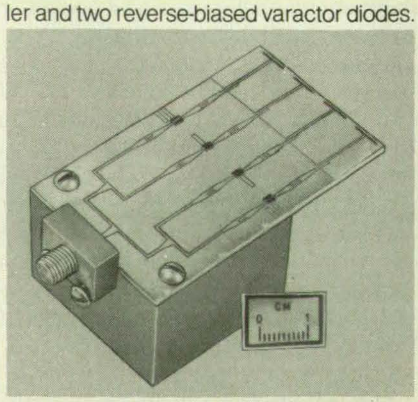


Figure 2. The **Prototype Antenna** was fabricated on a printed-circuit board 0.0625 in. (1.59 mm) thick.

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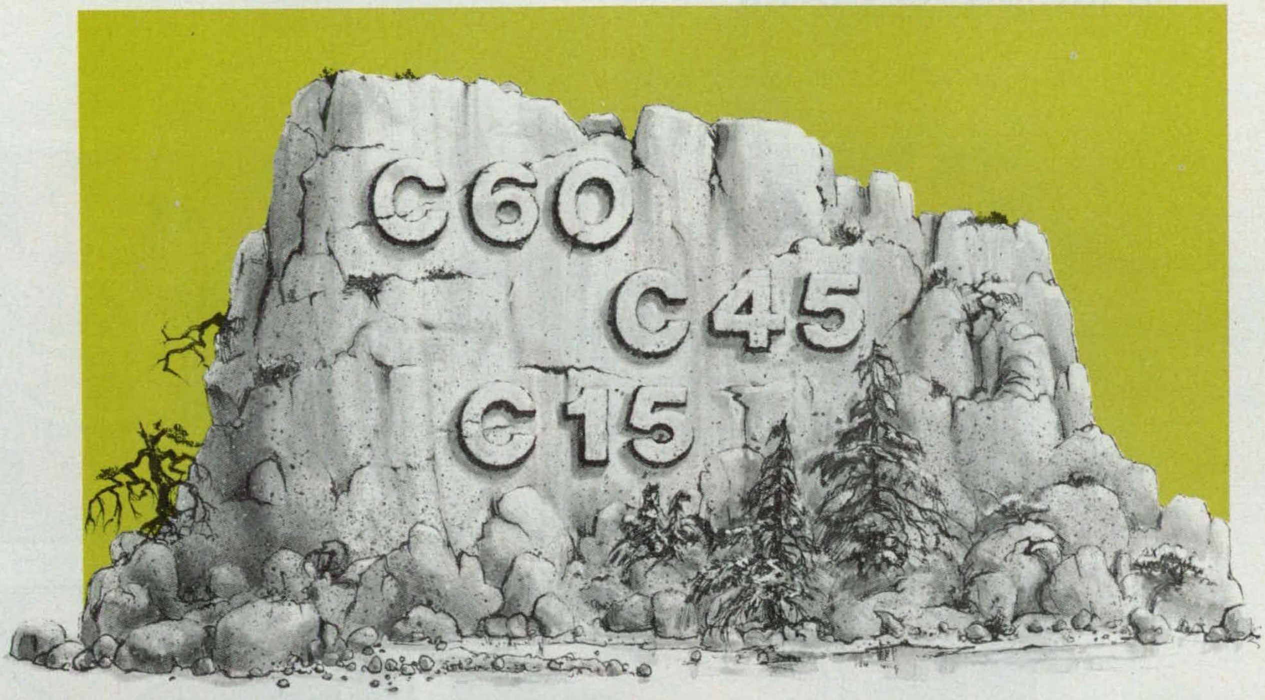

25 years of solid state relay experience—commercial/industrial experience since 1968. All of our products (past, present and future) contain that know-how. Our price/performance ratios are better than ever. Please review the following product examples:

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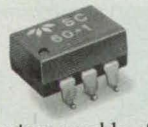
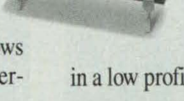

Surface Mount Shown

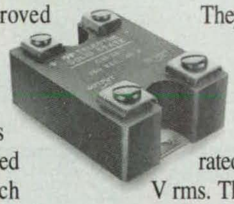
Housed in a 6 pin mini-DIP, the C60 Series is a family of bi-directional FET output solid state relays capable of controlling ac, bi-directional or dc loads. The optically coupled C60 handles a broad range of switched voltages (up to ± 360 Vdc) and currents (up to 1.0 Arms /2.0 Adc). The unique three terminal output allows the user to parallel the output FETs externally for dc operation ensuring low on resistance down to 0.075 ohms.

C45



The C45 has a significantly improved price/performance ratio. This series of solid state ac relays are optically isolated. The units contain back-to-back photo SCRs and a zero crossing circuit developed by Teledyne. The tight zero switch window ensures reliable transient free switching of AC loads and very low EMI and noise generation. The optical isolation of control from output affords noise free power switching. This series can switch from 10 ma to 1.0 amp rms at 250 Vrms. The C45 is packaged in a low profile 16 pin DIP package.

C15



The C15 ac solid state relays are truly valued engineered, employing back-to-back SCRs with a zero crossing turn on circuit. They also provide transient free switching of AC loads and very low EMI and noise generation. This series of solid state relays has versions rated from 10 to 40 amp rms at 250 V rms. These units are packaged in the familiar industry standard configuration.

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For More Information Write In No. 427

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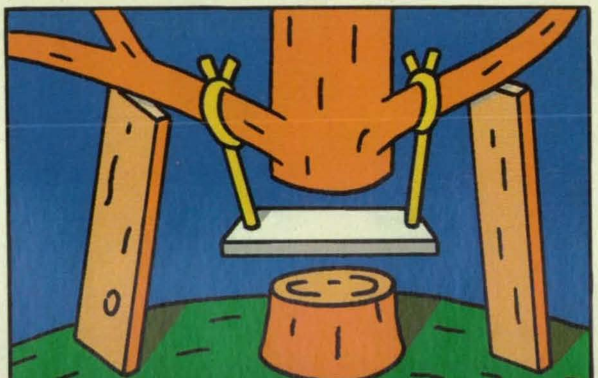
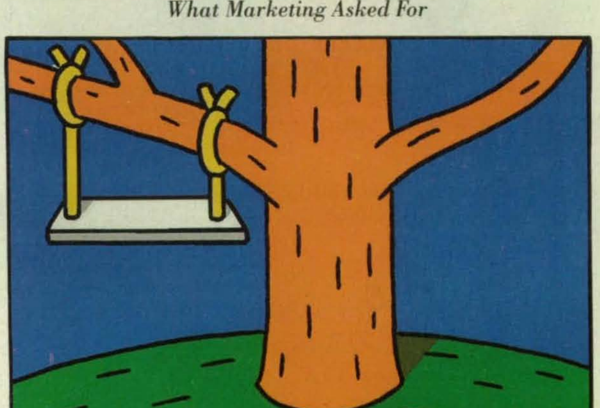
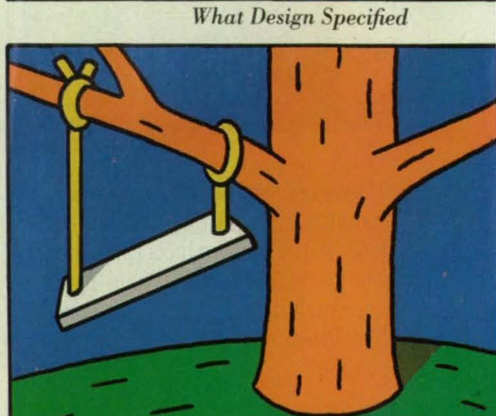


What Marketing Asked For

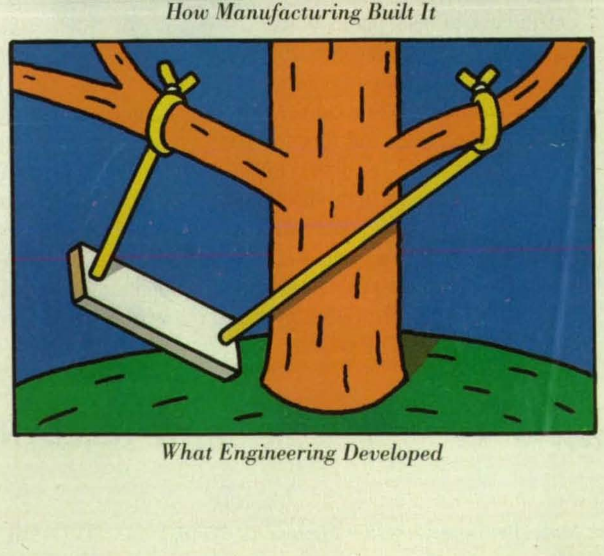
What Design Specified



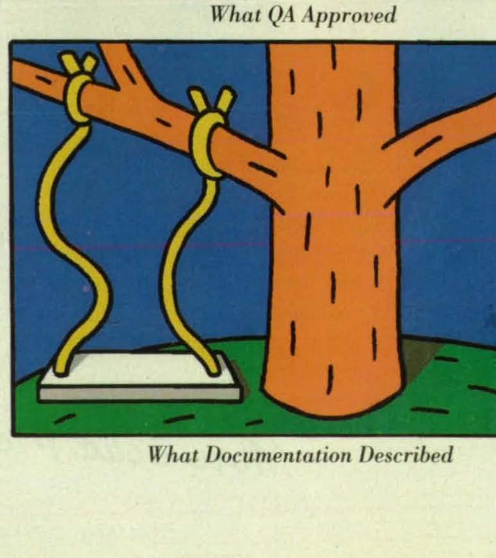
How Manufacturing Built It



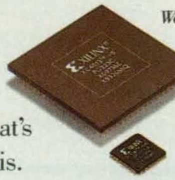
What QA Approved



What Engineering Developed



What Documentation Described



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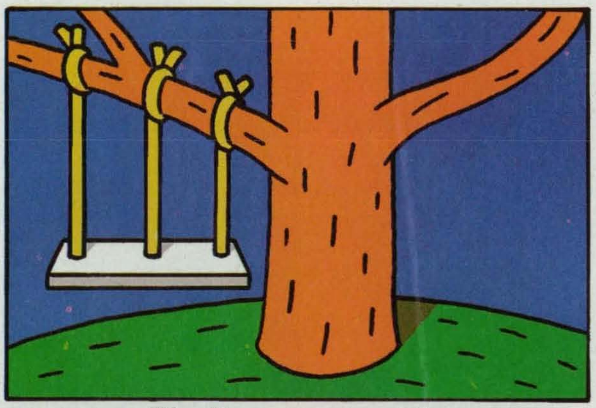
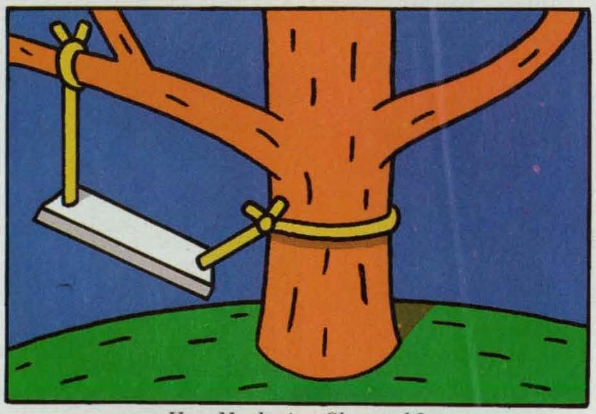
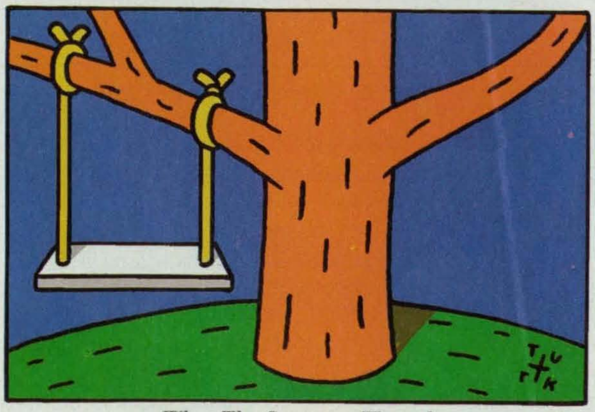


What Management Agreed On



How Marketing Changed It



What The Customer Wanted

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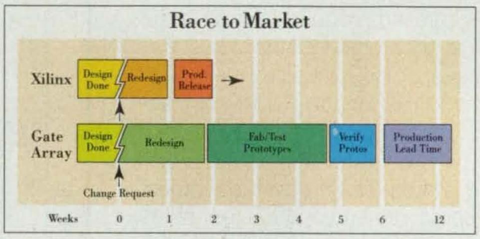

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For More Information Write In No. 593

By variation of the reverse bias from 0 to 4 V, one can change the phase shift continuously over a range of 170°. If MMIC amplifiers, variable attenuators, and/or switches were added, one could then also vary the amplitudes of the signals fed to the radiating elements.

The radiation pattern of the antenna was measured with 50-Ω microstrip "through" connections in place of the MMIC phase shifters. The radiation patterns in the electric- and magnetic-field planes were found to have 3-dB angular widths of 15° and 40°, respectively. The average insertion loss of the MMIC phase shifters tested as separate components was found to be 6.15 dB.

This work was done by G. E. Ponchak and R. Q. Lee of **Lewis Research Center**, *R. N. Simons of Sverdrup Technology, Inc., and N. S. Fernandez of the University of Puerto Rico. Further information may be found in NASA TM-102522 [N90-21273] "Coplanar Waveguide Fed Phased Array Antenna."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LEW-15183

X-Band/Ka-Band Dichroic Plate

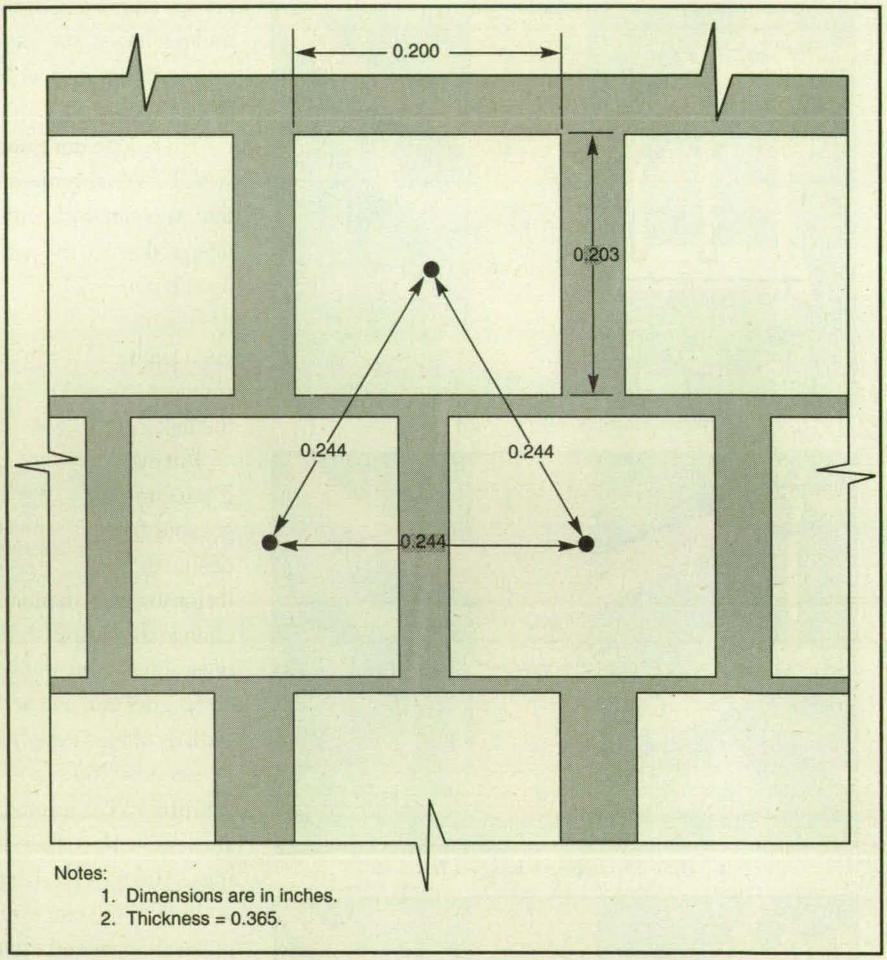
Grating lobes were taken into account in improving the design.

NASA's Jet Propulsion Laboratory, Pasadena, California

A dichroic plate is designed to be nearly transparent to circularly polarized microwaves at frequencies between 31.8 and 34.7 GHz (in and near the Ka band) and reflective at frequencies between 8.4 and 8.5 GHz (in the X band). The plate would be made of electrically conductive material and would contain rectangular holes in the staggered pattern shown in the figure.

The holes are required to be large enough to accommodate the lowest Ka-band frequency but packed tightly enough to prevent grating lobes at the highest frequency. The wider the band between these two frequencies, the more severe the grating-lobe problem becomes. In choosing dimensions of the holes and the spaces between them, one must also take account of the requirement for adequate wall thickness so that the plate can support itself.

The dimensions of an initial dimensions of the design were scaled from those of an S-band/X-band test dichroic plate. The transmission loss of radiation in the transverse magnetic (TM) and transverse electric (TE) linear polarizations had not been optimized in the design of the test plate; consequently, the dimensions of the holes, the distances between the holes, and the thickness of the plate were adjusted to meet this requirement: specifically, to reduce transmission loss to ≤0.2 dB in a subband of 33.6 to 33.8 GHz.



The **Dichroic Plate** is a conductive plate that contains rectangular holes in this pattern.

In general, the angle of transmission through a dichroic plate is equal to the angle of incidence (principal direction). However, depending on the angle of incidence, the frequency, and the pattern of holes in the plate, modes of higher order can be excited, causing some of the transmitted power to leave at an angle other than the principal direction. This power forms the grating lobes in the radiation pattern, which are similar to the grating lobes in the radiation patterns of phased-array antennas. Inasmuch as the radiation incident on the plate in the intended application would contain curved wave fronts diverging from a feed horn instead of an ideal plane wave front, grating lobes could be generated by portions of the horn radiation that would strike the plate at large angles of incidence.

To investigate this possibility, the grating-lobe effects in the dichroic-plate/feed-horn system were studied in three steps. First, grating lobes that could be excited by a plane-wave illumination were computed. Next, feed-horn radiation patterns were computed in terms of groups of plane waves traveling at different angles. Finally, these plane-wave expansions were used to compute the grating lobes that would be excited by the radiation from the feed-horn.

The results of these theoretical calculations indicated excellent performance in a subband between 31.8 and 32.3 GHz, and transmission loss ≤0.2 dB, as required, in the 33.6- to 33.8-GHz subband. The computations also predict that there should be no grating-lobe problem in these subbands, but that there may be grating-lobe effects near the maximum frequency of 34.7 GHz.

This work was done by Jacqueline C. Chen of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 10*** *on the TSP Request Card.* *NPO-18572*

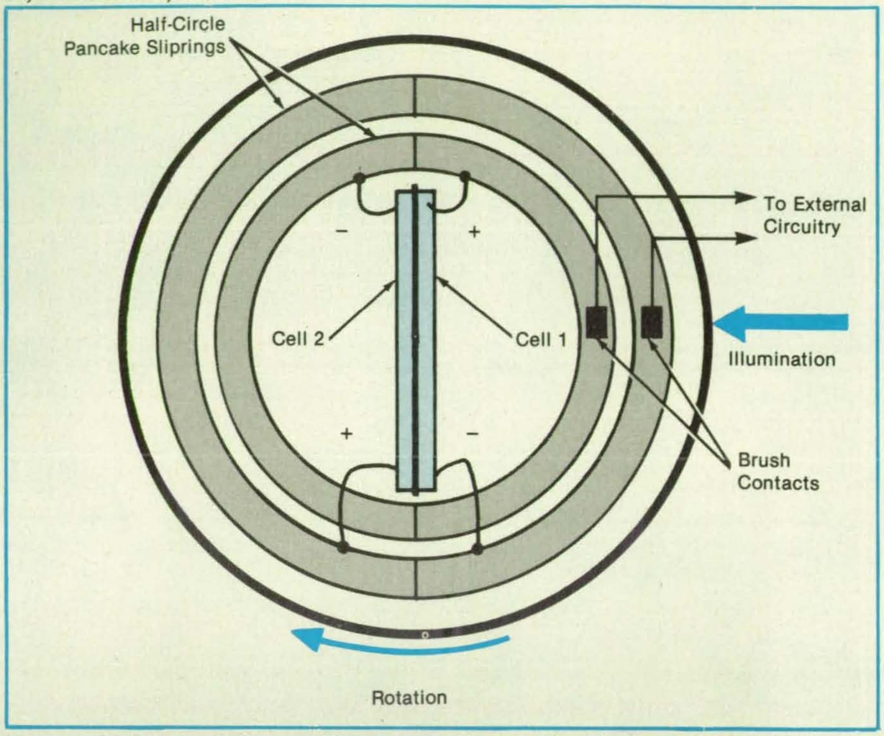
Generating AC With Rotating Solar Cells

Inverter circuits would not be necessary.

Lyndon B. Johnson Space Center, Houston, Texas

Rotating solar photovoltaic cells or batteries connected to suitable mechanical and/or electronic commutators would produce nearly sinusoidal alternating current, according to a proposal. Taken by itself, a solar cell or battery produces direct current only; if ac is needed, then the dc output must be converted to ac. In a typical solar power system in use at present, this conversion is effected by inverter circuitry. The proposed method of generating ac from solar cells would eliminate the need for inverter circuitry and its attendant power-consumption and heat-dissipation problems, but would impose a need for a low-power-consumption rotary mechanism.

The output voltage of a photovoltaic cell or battery under load closely approximates a cosinusoidal function of the angle of incidence of light on its front face. Thus, if a cell or battery is rotated at constant speed about an axis perpendicular to the direction of illumination, it would produce a nearly sinusoidal waveform during each half cycle of rotation. If two cells or batteries were mounted back to back and so rotated, then one would produce a nearly sinusoidal waveform during one half cycle, while the other would do so during the other half cycle.



Back-to-Back Solar Cells would be connected in opposite polarities to half-circle sliprings and rotated, producing a nearly sinusoidal alternating voltage at the brush contacts.

As shown in the figure, two rotating back-to-back cells or batteries could be connected with opposing polarities to half-circle pancake sliprings, which would be connected to external circuitry via brush contacts. Together, the sliprings and brush contacts would serve as a commutator, so that the brush contacts would carry the voltages of opposing polarity on alternate half cycles. The frequency of alternation is simply the frequency of rotation.

In a similar manner, three-phase ac power could be obtained from an assembly of three pairs of rotating cells oriented 120° relative to each other. Although this method of generating ac power was intended originally for use aboard spacecraft, it may be useful in special terrestrial situations; e.g., where solar electric power must be transmitted over powerlines from one remote location to another. One of the disadvantages of this method is that the ac power produced could be no more than about 32 percent of the dc power available from the same cells or batteries.

This work was done by David T. Flanagan of Krug International for **Johnson Space Center**. *For further information,* ***write in 5*** *on the TSP Request Card.*
MSC-22057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Edge-Geometry SNS Devices Made of Y/Ba/Cu/O

Advantages include desirable electrical characteristics and less difficulty in fabrication.

NASA's Jet Propulsion Laboratory, Pasadena, California

Superconductor/normal-conductor/superconductor (SNS) devices in which the electronically active layers consist solely of materials in the Y/Ba/Cu/O system have been fabricated in an edge geometry. Edge-geometry SNS devices made of different materials were described in "SNS Device Made With Edge-Defined Geometry" (NPO-18303), *NASA Tech Briefs*, Vol. 16, No. 6 (June 1992), page 24. As before, the basic plan is to fabricate two superconductor layers (in this case, $YBa_2Cu_3O_{7-x}$) connected by a normal-conductor bridge (in this case, a nonsuperconducting Y/Ba/Cu/O phase).

The electrical characteristics depend critically on the dimensions of the bridge: typically, the bridge must have a micron

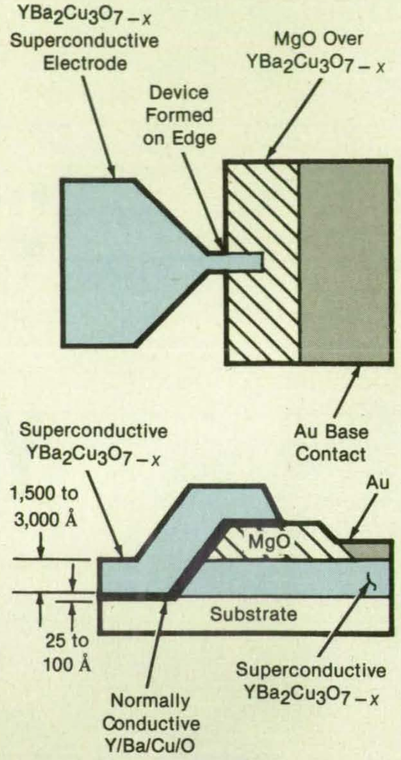

Figure 1. A **Y/Ba/Cu/O Edge-Geometry SNS Device** is fabricated by a combination of epitaxial deposition, ion milling, photolithography, and other techniques commonly used to make integrated circuits.

or submicron cross section to provide sufficient impedance for coupling to external circuitry, and the length of the bridge must be less than about 5 times the 20-Å coherence length of the nonsuperconducting Y/Ba/Cu/O normal metal layer to ensure adequate coupling of superconductivity. The edge geometry simplifies the fabrication of submicron cross-sectional area bridges, and enables production of very short bridge lengths because the length of the bridge is determined by the thickness of the deposited layer of normally conductive material (see Figure 1).

The fabrication of a device of this type begins with the formation of a first thin superconductive film of *c*-axis-oriented $YBa_2Cu_3O_{7-x}$ covered by a thick insulating layer of MgO. Then the MgO is used as an ion milling mask to pattern an edge in the base Y/Ba/Cu/O layer and normally conductive Y/Ba/Cu/O (possibly oxygen-deficient $YBa_2Cu_3O_{7-x}$) is deposited on the exposed edge. Finally the second super-

conductive $YBa_2Cu_3O_{7-x}$ layer is deposited over the Y/Ba/Cu/O layer. The use of Y/Ba/Cu/O as normally conductive bridge material offers the advantage of chemical compatibility with the superconductive $YBa_2Cu_3O_{7-x}$ layers. It has also been conjectured that the Y/Ba/Cu/O layer offers a good crystal-lattice match for the epitaxial deposition of the second superconductive $YBa_2Cu_3O_{7-x}$ layer.

The devices exhibit electrical characteristics consistent with the model of resistively shunted Josephson junctions (see Figure 2), with strong microwave and magnetic-field responses at temperatures up to 85 K. These characteristics make the devices attractive for development into high-frequency oscillators, magnetic-field sensors, and submillimeter-wave mixers.

This work was done by Brian D. Hunt of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 79*** *on the TSP Request Card.*

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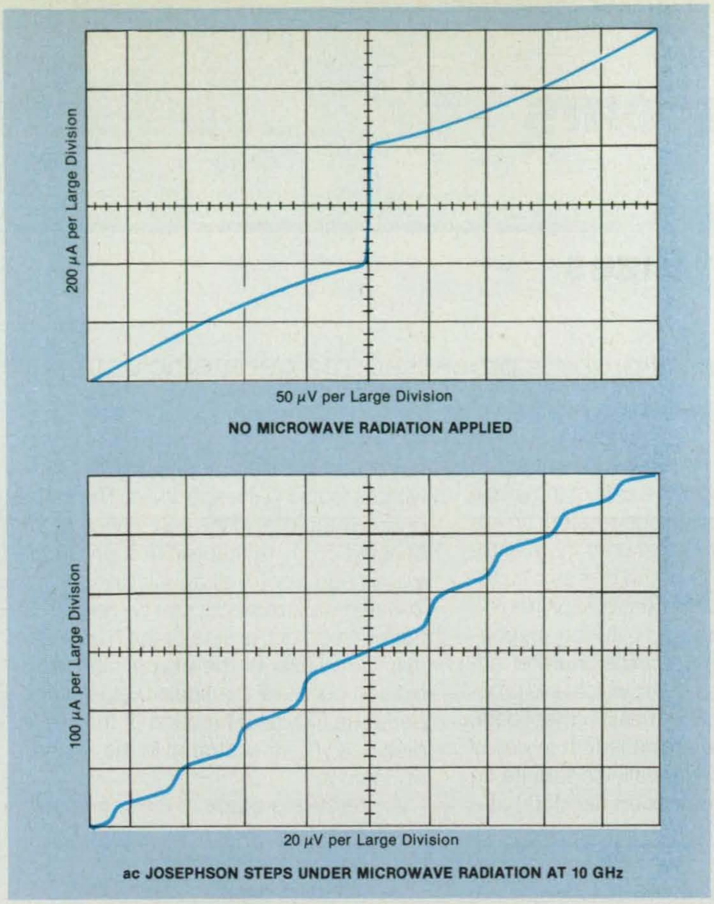


Figure 2. These **Current-vs.-Voltage Curves** of an SNS device that includes a 50-Å normally conducting Y/Ba/Cu/O layer were measured at a temperature of 61.5 K.

Noncontact Measurement of Sizes and Eccentricities of Holes

The output of a rotating, translating eddy-current probe is processed into geometric data.

Goddard Space Flight Center, Greenbelt, Maryland

A semiautomatic eddy-current-probe apparatus makes noncontact measurements of nominally round holes in electrically conductive specimens and processes the measurement data into diameters and eccentricities of the holes. The apparatus (see Figure 1) includes an x–y translation platform, which holds a specimen and moves it horizontally. The probe is mounted on a probe scanner, which positions the probe along the vertical (z) direction and rotates the probe about its vertical axis at a preset low speed — typically, 6 rpm. An eddy-current sensing coil is mounted in the side of the probe near the tip. As the probe rotates, an impedance analyzer measures the electrical impedance (**Z**) of the coil as a function of the instantaneous rotation angle.

The translation and rotation mechanisms and the impedance analyzer are controlled by a computer, which also processes the impedance-measurement data. In operation, the probe is first lowered automatically or manually so that its tip reaches a predetermined depth (z) at a horizontal position (x, y) within the hole without touching the specimen. The probe is then rotated, and the impedance of the sensing coil is measured at a predetermined number (n) of angular positions. These measurements can be related to the position of the side of the hole (relative to the axis of the probe) via a calibration curve of the scalar value of impedance ($|\mathbf{Z}|$) as a function of the lift-off distance (l), as illustrated in the left part of Figure 2.

An iterative process of measurement,

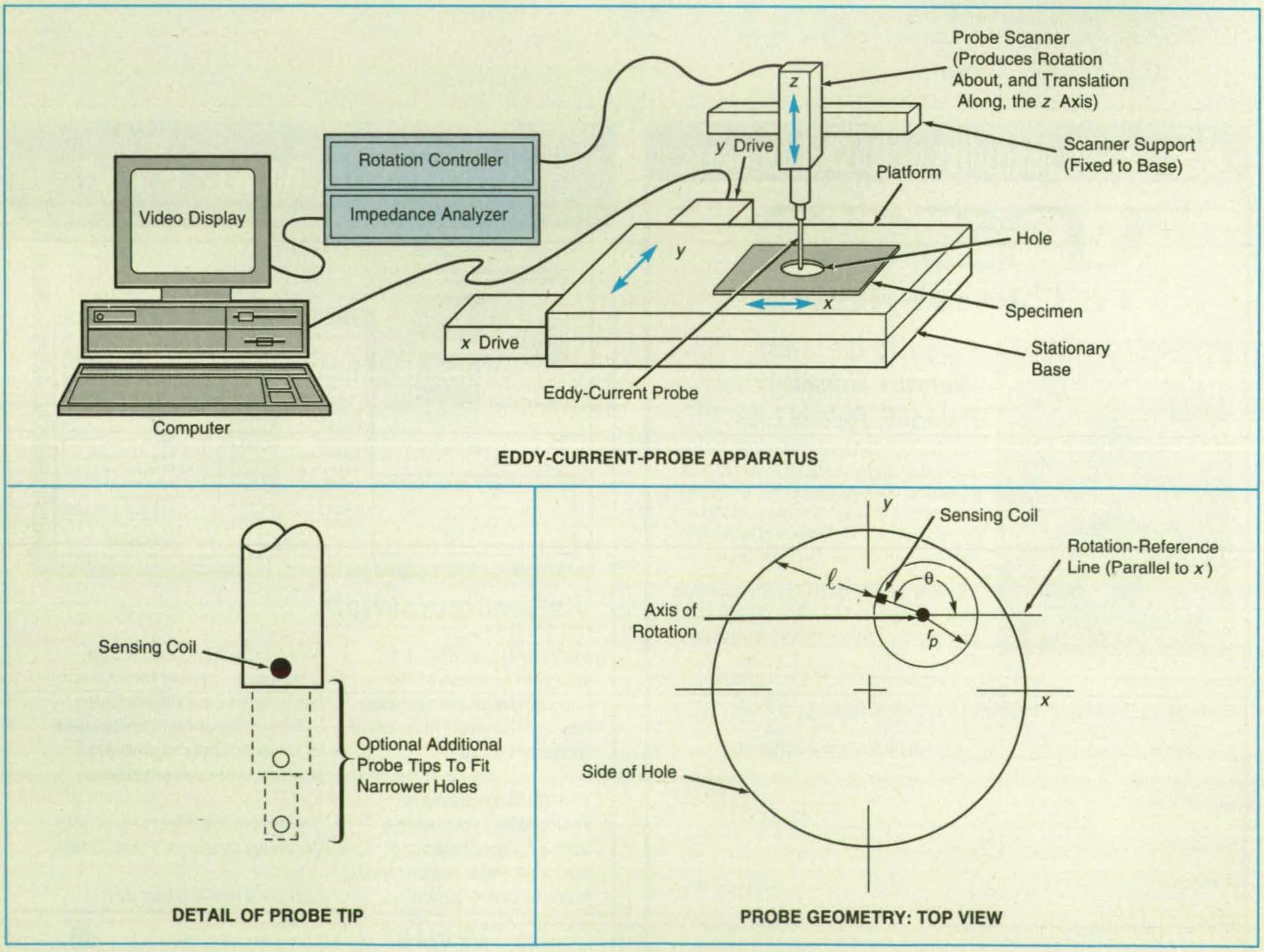


Figure 1. The **Eddy-Current Probe** contains one or more sensing coil(s) near its tip. At each position x, y, z, the probe is rotated slowly about the z axis and its impedance is measured at a number of rotation angles.

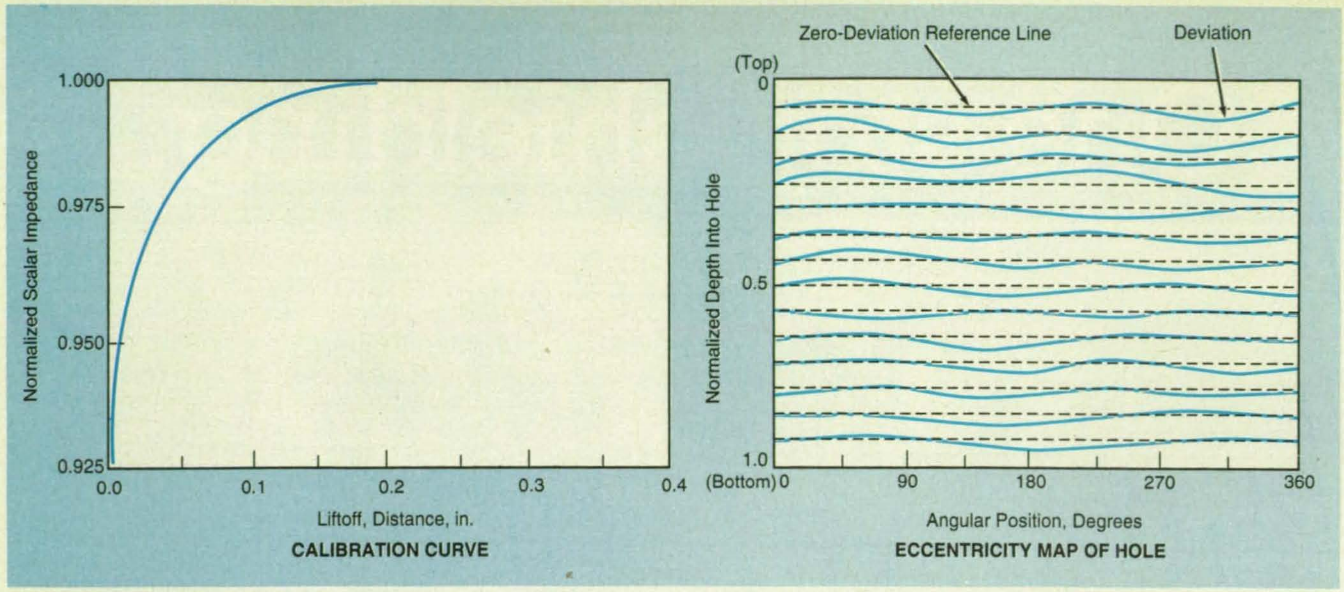


Figure 2. The **Impedance of the Sensing Coil** varies with the lift-off distance (l), which, in turn, varies with the rotation angle (θ). Once x and y have been set at the center of the hole by an iterative process of measurement, computation, and adjustment, the eccentricity of the hole can be determined from the impedance as a function of angle. This process can be repeated at different vertical positions to obtain an eccentricity map of the entire inner surface of the hole.

processing, and adjustment is used to locate the center of the hole and to determine its diameter and eccentricity: From the impedances $\mathbf{Z}_i$ measured at each of the rotation angles (i = 1 to n), at position x, y, the computer calculates the average scalar value of impedance,

$$|\bar{\mathbf{Z}}| = \sum_{i=1}^{n} |\mathbf{Z}_i|$$

Then it calculates the composite deviation, σ, which is the root-mean-square deviation of the scalar values of impedance from the average scalar value of impedance;

$$\sigma = \left\{ \left[\sum_{i=1}^{n} \left(|\mathbf{Z}_i| - |\bar{\mathbf{Z}}| \right)^2 \right] \Big/ n \right\}^{1/2}$$

The center of the hole is deemed to be located at the x, y position where the value of σ is at its minimum. The effective diameter is then determined from (1) the $|\mathbf{Z}|$ at this position, (2) the $|\mathbf{Z}|$-vs.-l calibration curve, and (3) the known radius of the probe. Then again using the $|\mathbf{Z}|$-vs.-l calibration curve with each $|\mathbf{Z}_i|$, the computer calculates the eccentricity (the deviation of the surface of the side of the hole from the surface defined by the effective diameter). The eccentricity as a function of angle can be plotted for a sequence of depths, z, to yield a map of eccentricity over the entire inner surface of the hole, as shown in the right part of Figure 2.

This work was done by Engmin J. Chern of **Goddard Space Flight Center**. *For further information,* ***write in 85*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center [see page 22]. Refer to GSC-13504.

Bilateral Impedance Control for Telemanipulators

Relationships between forces and positions can be modulated to suit the requirements of tasks.

Langley Research Center, Hampton, Virginia

A telemanipulator system includes a master robot that is manipulated by a human operator, and a slave robot that performs tasks at a remote location. The two robots are electronically coupled so that the slave robot moves in response to commands from the master robot. Teleoperation is greatly enhanced if the forces acting on the slave robot are fed back to the operator. This gives the operator the feeling that he or she is manipulating the remote environment directly. Systems that provide force reflection from the environment are called bilateral because information travels in both directions between the master and slave.

Bilateral impedance control is a method of controlling telemanipulators. This method differs from older methods in that interaction forces instead of position or velocity signals are used as the communication signals between the master and slave robots. The main advantage of bilateral impedance control is that it enables the arbitrary specification of desired performance characteristics for a telemanipulator system. The relationship between force and position can be modulated at both ends of the system to suit the requirements of the task.

Bilateral impedance control performed successfully in a demonstration on a NASA laboratory telerobotic manipulator that had seven degrees of freedom. The principle of operation can be explained more easily via an example of a telerobotic system that has one degree of freedom (see figure). Both robots are equipped with end-point force sensors. The master robot force sensor measures the interaction force with the human (the hand force), f_m. The slave robot force sensor measures the interaction force with the environment, f_s.

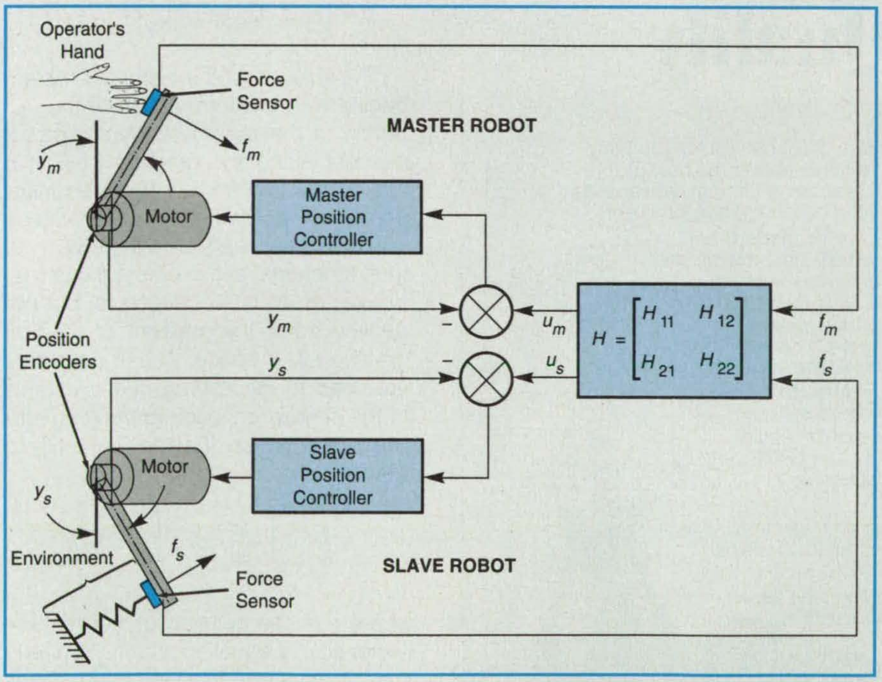
The robots are stabilized by independent, closed-loop position controllers. The position controllers keep the robots stationary when the human is not interacting with the system. The position of the master robot, y_m, depends on two inputs: the electronic drive signal, u_m, applied to the master position controller, and the force, f_m, applied to the robot by the human arm. Similarly, the position of the slave robot, y_s, depends on the electronic drive signal, u_s, applied to the slave position controller, and on the reaction force, f_s, exerted on the robot by the environment.

The flow of force signals within the telerobotic system is regulated by the H matrix, which consists of compensators H_{11}, H_{12}, H_{21}, and H_{22}. These compen-

sators filter the interaction forces f_m and f_s to produce the electronic drive signals u_m and u_s, which are applied to the robot position controllers. The compensator H_{11} filters the master force, f_m, and its output is used to drive the master robot. In effect, H_{11} governs the relationship between master force, f_m, and position, y_m. By choosing a large gain for H_{11}, it is possible to reduce the impedance of the master robot. This helps the human operator to overcome easily the inherent resistance of the robot to motion.

The impedance of the slave robot is controlled in a manner similar to that of the master robot. The compensator H_{22} filters the slave force, f_s, and its output constitutes part of the drive signal, u_s, applied to the slave position controller. H_{22} generates compliance in the slave robot. Compliance is necessary for stability of the system, and it prevents the buildup of large contact forces in interactions with a rigid environment.

The bilateral communication between the master and slave is regulated by the compensators H_{12} and H_{21}. The master force is filtered through the compensator H_{21}, the output of which constitutes the forward part of the drive signal, u_s, applied to the slave robot. Similarly, the slave force, f_s, is filtered through



Bilateral Impedance Control provides adjustable relationships among forces and positions at the master and slave robots.

compensator H_{12}, the output of which constitutes the backward (force-reflecting) part of the drive signal, u_m, applied to the master position controller.

The performance characteristics of the telerobotic system can be specified arbitrarily by proper selection of the relative magnitudes of the elements of the H matrix. For many tasks, it is desirable to specify the ratio between the robot forces. This enables the human to command the slave robot to apply a large force by applying a small hand force to the master robot. In addition, it is often desirable to specify the ratio between the motions of the robots. For example, the slave robot can be made to perform small, precise motions in response to large, coarse motions of the master robot. This position scaling has applications in microsurgery.

This work was done by Christopher L. Moore of **Langley Research Center**. *For further information,* ***write in 2*** *on the TSP Request Card.*
LAR-14903

Adjoint-Operator Learning for a Neural Network

Temporally varying patterns could be learned in real time.

NASA's Jet Propulsion Laboratory, Pasadena, California

Electronic neural networks could be made to synthesize initially unknown mathematical models of time-dependent phenomena or to learn temporally evolving patterns by use of algorithms based on adjoint operators. For example, a neural network could be "taught" to recognize a moving object in an image. The algorithms of the proposed adjoint-op-

erator method would be less complicated than are prior algorithms developed for the same purpose. The prior algorithms involve large amounts of computation and they involve the solution of equations backward in time, thereby necessitating the storage of large numbers of intermediate data and precluding real-time applications. The algorithms of the proposed method would involve less computation and would solve learning equations forward in time possibly simultaneously with the equations of evolution of the neural network, thereby both increasing the computational efficiency and making real-time applications possible.

In developing the adjoint-operator method, the evolution of a neural network is considered to be governed by the following set of coupled nonlinear differential equations:

$$\dot{u}_n + \kappa_n u_n = \sum_m T_{nm}\, g(\gamma_m u_m) + {}^kI_n$$

where u_n represents the output of the nth neuron and T_{nm} denotes the synaptic coupling from the mth to the nth neuron. The constant κ_n characterizes the decay of neuron activity. The response of a neuron is governed by sigmoidal function g and gain γ_m; typically, $g(\gamma_m z) = \tanh(\gamma_m z)$. The time-dependent term ${}^kI(t)$, called the "source" term, encodes the contribution of the nth component of the kth temporal pattern ${}^k\bar{a}(t)$ to be learned via the expression

$${}^kI_n(t) = \begin{cases} [{}^ka_n(t) - g[\gamma_n u_n(t)]]^\beta \\ \text{if } n \text{ denotes an input neuron} \\ 0 \text{ if } n \text{ denotes a hidden or} \\ \text{output neuron} \end{cases}$$

When $\beta = (2i+1)^{-1}$ and i is a positive integer, the source function induces terminal-attractor dynamics for static patterns, and provides opportunity for learning static phenomena in real time.

The problem in learning is to adjust the T_{nm}, γ_m, and κ_n in such a way as to minimize a quantity called the "neuromorphic energy functional," E, given by

$$E(\bar{u},\bar{p}) = \int_t \frac{1}{\alpha} \sum_k \sum_n {}^k\Gamma_n^\alpha \, dt = \int_{t_o}^{t_o+\Delta t} F\, dt$$

where t = time, the integral is taken over some finite interval, and

$${}^k\Gamma_n(t) = \begin{cases} {}^ka_n(t) - g[\gamma_n u_n(t)] \text{ if } n \text{ denotes} \\ \text{an input or output neuron} \\ 0 \text{ if } n \text{ denotes a hidden neuron} \end{cases}$$

Typically, α is a positive value such as 2. The vector $\bar{p}$ denotes the system of parameters:

$$\bar{p} = \left\{T_{11}, \dots T_{NN} \middle| \kappa_1, \dots {}_{NN} \middle| \gamma_1, \dots \gamma_N \middle| \right\}$$

The solution of the learning problem begins with the formulation of the updating of the parameter vector $\bar{p}$ as a descent along the gradient of E in $\bar{p}$ space, starting from a guessed initial parameter vector. The adjoint operators, which are not really operators but, rather, functions, are expressed in a matrix•vector equation related to, but not derived from, the gradient of the first equation in $\bar{p}$ space. These operators are used to incorporate the dynamics of the neural network into the gradient-descent equation, leading eventually to the following equation:

$$\frac{dE}{dp_\mu} = \int_t \frac{\partial F}{\partial p_\mu} dt + \int_t \bar{v}\, {}^k\bar{s}_{,\mu}\, dt$$

where $\bar{v}$ is the solution of the matrix•vector adjoint equation and ${}^k\bar{s}_{,\mu}$ is a tensor that arises when taking the gradient of the first equation in $\bar{p}$ space. This equation is integrated forward in time, concomitantly with the first equation.

This work was done by Jacob Barhen and Nikzad Toomarian of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 124*** *on the TSP Request Card.*
NPO-18352

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Physical Sciences

Pyrometry Without Spurious Reflections

Measurements are not contaminated by reflected radiation from furnace walls.

NASA's Jet Propulsion Laboratory, Pasadena, California

The temperature of a heated spherical specimen of opaque material with a specular surface can be measured by optical pyrometry, without need to correct for the effect of reflected thermal radiation upon measured radiances, provided that the reflections are eliminated. A method of eliminating the reflections is described in the subsequent paragraphs. The method should be particularly useful for making accurate noncontact measurements of levitated specimens (which are almost always spherical and specular) of molten metal and other materials in containerless processing.

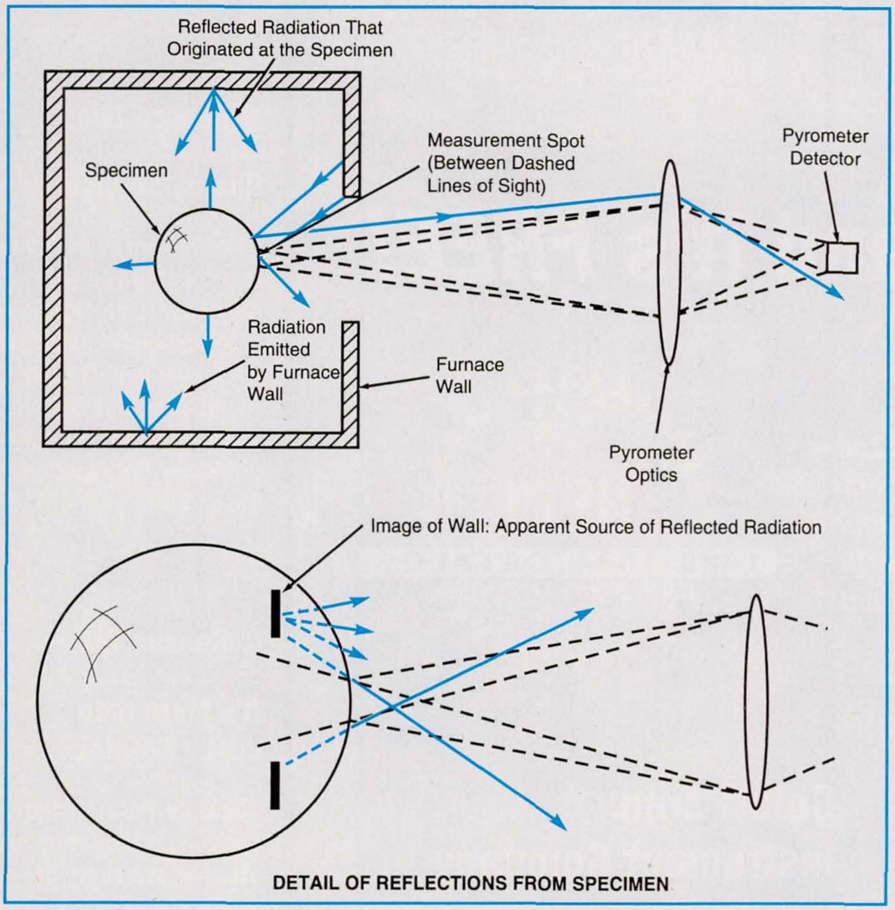
Some of the spurious reflected radiation (see upper part of figure) originates on the wall of the furnace; some originates elsewhere and is reflected from the walls of the furnace. This spurious reflected radiation can be even more intense than that from the specimen itself, especially when the walls of the furnace are used to heat the specimen radiantly. To eliminate the need to correct pyrometric readings, it is necessary to prevent the reflection of this radiation from the specimen into the pyrometer along with the direct thermal radiation from the specimen that one seeks to measure.

The method of preventing the unwanted reflections is based on the fact that light that travels from the furnace and that is specularly reflected from the specimen is restricted to a well-defined range of optical paths. By proper choice of the dimensions and locations of the specimen, viewing aperture in the furnace, and pyrometer, one can ensure that this range of optical paths does not include the path to the detector in the pyrometer.

The lower part of the figure illustrates the problem in simplified form. The specimen acts as a spherical mirror, so that radiation from one wall of the specimen that is reflected from the specimen appears to originate from an imaginary surface within the sphere. This imaginary surface is the image of the wall that contains the aperture. No wall radiation comes from the image of the aperture at the center of this imaginary surface. To keep out the unwanted reflections, it is necessary to aim the pyrometer toward a measurement spot on the surface of the specimen in front of the image of the aperture, and the measurement spot (the projection of the pyrometer optics onto the specimen) must be small enough that the field of view of the pyrometer does not extend out to the edge of the image of the aperture. The analysis is fairly simple in the paraxial-ray approximation; in a case in which this approximation is invalid, it is necessary to use the exact equations of large-angle reflections from a specular spherical surface, in their full complexity, to find an arrangement that will prevent unwanted reflections into the pyrometer.

This work was done by Andrew S. W. Thomas of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 42*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office–JPL [see page 22]. Refer to NPO-18655.



Radiation From the Wall Is Reflected from the spherical specimen. It should not be allowed to enter the pyrometer detector. If it does, then the pyrometer reading is distorted. To prevent unwanted reflections, the apparatus must be arranged so that the field of view of the pyrometer does not contain any lines of sight to the image of the wall.

Conically Scanned Holographic LIDAR Telescope

A rotating holographic optical element performs both focusing and scanning functions.

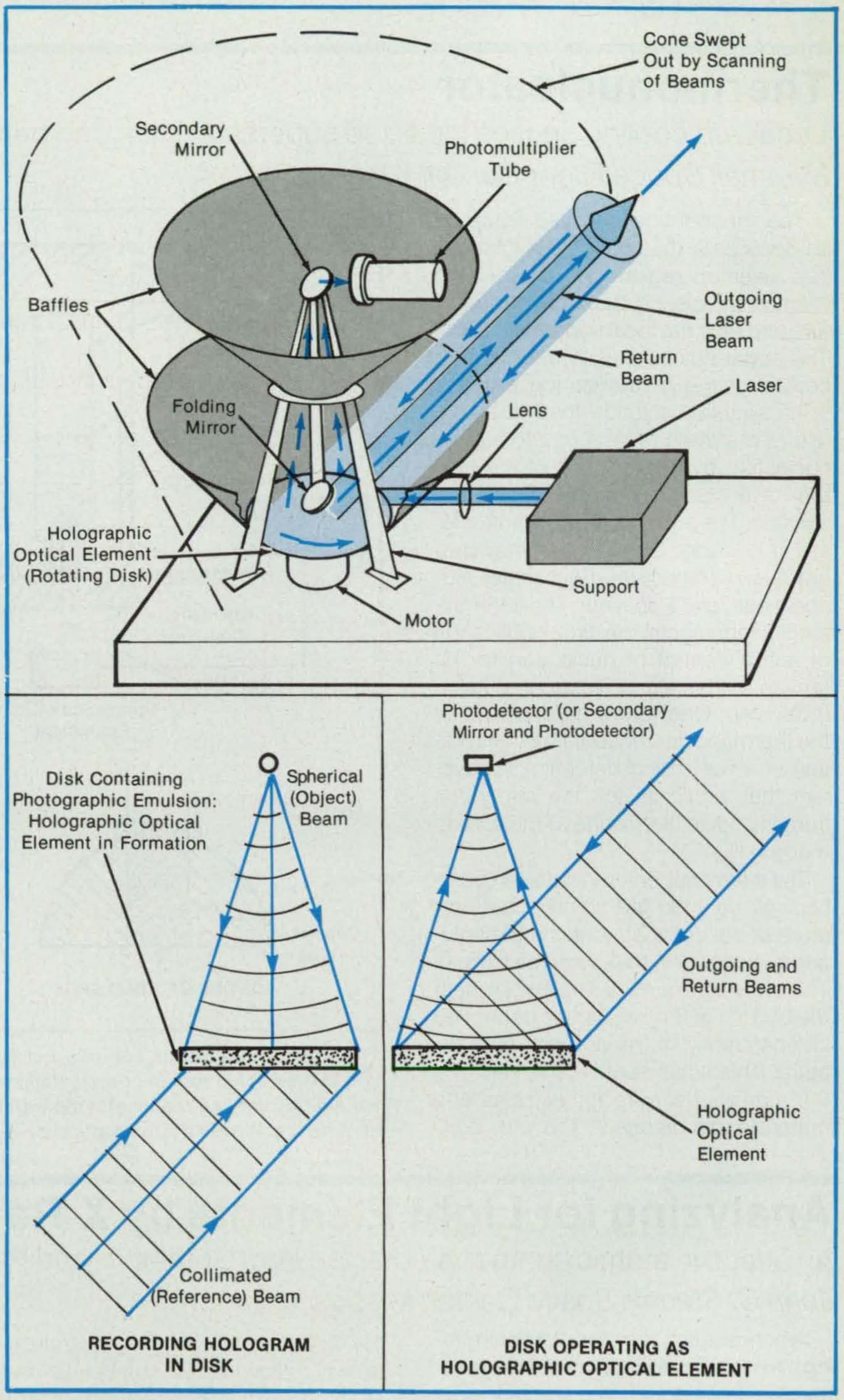
Goddard Space Flight Center, Greenbelt, Maryland

The figure depicts schematically a proposed lightweight, large-aperture (diameter ≥1 m) telescope suitable for light detection and ranging (LIDAR) or laser remote sensing. The telescope would include a rotating holographic optical element in the form of a disk. The rotation, about a constant axis through the center of the disk, would sweep the outgoing laser beam and the return beam around a cone, while the holographic optical element would focus the return beam toward a stationary point on the axis of rotation. A stationary secondary mirror on the axis of rotation would reflect the focused return beam onto a photomultiplier or other suitable detector. A small stationary mirror located a short distance above the holographic disk would reflect the beam from the laser down onto the disk, where diffraction would effectively reflect this beam outward along the scanning optical path.

The rotating mass of the holographic telescope would be much less than that of an equivalent telescope based on conventional mirrors and/or lenses. Also, unlike in a conventional telescope, there would be little or no need for separate optical blocking and interference filters to reject light at unwanted wavelengths, particularly scattered solar radiation, because the holographic disk would inherently diffract and focus only light in a narrow wavelength band or bands onto the detector (as required in a laser remote sensing system).

The holographic disk would be produced by recording an interference pattern in a photographic emulsion supported on a transparent substrate. Two mutually coherent laser beams would impinge on the emulsion from opposite sides to form the interference pattern: One of these beams, called the "reference" beam, would be collimated; that is, it would contain plane wave fronts, and it would be made to impinge along the desired optical axis of the outgoing and return telescope beam. The other of these two beams, called the "object" beam, would contain spherical wave fronts expanding from a point source located on the optical axis above the disk.

Typically, an emulsion of this type contains ammonium dichromate (which is photosensitive) in gelatin. Upon exposure to light, ammonium dichromate produces chemical cross-links that harden the gelatin and increase its index of refraction. After exposure, the gelatin is washed to remove the dichromate, and the emulsion is processed further to fix the index-of-refraction interference pattern.



The **Holographic LIDAR Telescope** would include a holographic disk, the rotation of which would sweep a collimated, monochromatic beam of light from a laser through a conical scan. The holographic disk would diffract light scattered back from the target volume or area to the focal point located at the stationary photomultiplier detector. Two conical baffles would prevent stray light from reaching the detector.

A multiple-wavelength telescope based on the same principle could be produced in a variety of ways. Multiple holographic optical elements, each operating at a different wavelength, could be recorded in the same film. Separate holographic optical elements could be laminated together, each diffracting at its design wavelength and transparent at the design wavelengths of the others. If the wavelengths to be covered differed so much that the material of the holographic optical element for one

wavelength were not transparent at another wavelength, the different holographic optical elements could be separated spatially, say, into annuli or pie-shaped wedges.

The different wavelengths could be brought to focus at different distances along the optical axis. To reduce blocking of one detector by another, the light at each focal point could be picked up by a separate optical fiber for transmission to a separate remotely located detector.

This work was done by Geary Schwemmer of **Goddard Space Flight Center**. *For further information,* ***write in 39*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center [see page 22]. Refer to GSC-13462.

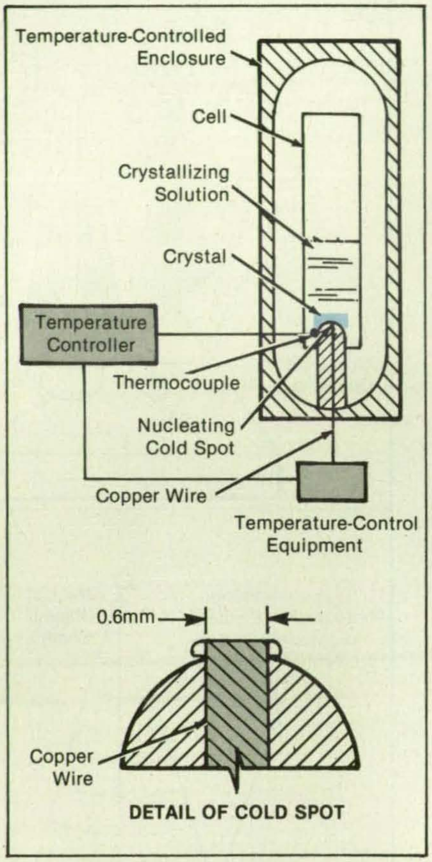
Thermonucleator

Localized cooling causes localized supersaturation and hence localized nucleation.

Marshall Space Flight Center, Alabama

The thermonucleator (see figure) is an apparatus that controls nucleation in a selected region of a crystallizing solution by varying the local temperature and thus the local supersaturation. This apparatus potentially offers better control of the crystallization process in an aqueous solution than does the use of a stream of cold gas to induce nucleation by cooling part of the bottom of a crucible that contains a hot solution. The ability of the thermonucleator to nucleate crystals in a small spot has been demonstrated with water, Rochelle salt, and lysozyme. The latter example represents the first application of active control of nucleation to the growth of crystals of biological macromolecules. One future modification of the thermonucleator could be the addition of a nucleation-detection subsystem that would switch the apparatus from the nucleation mode to the growth mode.

The thermonucleator includes a chamber that controls the ambient temperature of the cell that contains the solution from which crystals are to be formed. The temperature of a small spot near the bottom of the cell can be controlled independently of the ambient temperature. This small spot is the end of a 0.6-mm copper wire (other sizes and materials can be used). The wire is attached to a larger copper rod that dips into a Dewar flask that contains liquid nitrogen. The temperature of the small spot is controlled by use of a heater attached to the copper rod. Feedback is provided by a thermocouple and a temperature controller.



The **Thermonucleator** controls nucleation in a selected region of a crystallizing solution by varying the local temperature and, hence, the local supersaturation.

Local supersaturation and nucleation could also be induced and controlled by other techniques. For example, in the case of crystallization of biological macromolecules, the temperature-controlled wire could be replaced by a small source of precipitating agent to induce nucleation. Alternatively, the temperature-controlled wire could be replaced by an electrode, and electric current or the electric field between this electrode and another could be used to induce nucleation. Neither of these two concepts has yet been reduced to practice.

This work was done by Robert C. DeMattei and Robert S. Feigelson of Stanford University for **Marshall Space Flight Center**. *For further information,* ***write in 101*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 22]. Refer to MFS-26212.

Analyzing for Light Elements by X-Ray Scattering

An effective atomic number is obtained from Compton- and Rayleigh-scattering measurements.

John C. Stennis Space Center, Mississippi

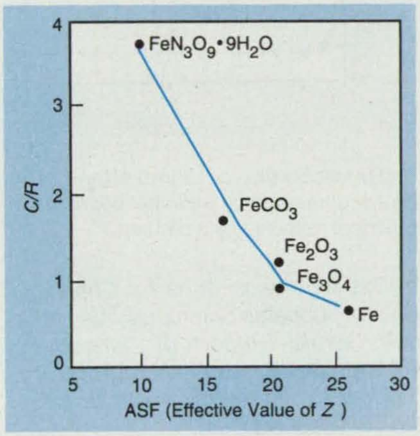
A nondestructive method of determining the concentrations of low-atomic-number elements in liquids and solids involves measurements of Compton and Rayleigh scattering of x rays. This x-ray-scattering method can be applied, for example, in the quantitative analysis of low-atomic-number constituents of alloys, of contaminants and corrosion products on surfaces of alloys, and of the fractions of hydrogen in plastics, oils, and solvents.

The impetus for the development of this x-ray-scattering method comes from the difficulty of performing quantitative analysis of low-atomic-number elements in another widely used method known as energy-dispersive x-ray fluorescence (EDXRF) spectroscopy. The difficulty is caused by three competing phenomena: (1) Auger emission reduces the intensity of fluorescence, (2) the relatively-low-energy fluorescence photons emitted by low-atomic-number elements are absorbed more strongly by surrounding material than are the higher-energy photons emitted by heavier elements, and (3) Compton (incoherent) scattering and Rayleigh (coherent) scattering make major contributions to the background spectrum, thereby interfering with the measurement of the fluorescence spectrum and limiting the analytical sensitivity.

Thus, Compton and Rayleigh scattering are considered a nuisance in EDXRF spectroscopy, but in the x-ray-scattering method, these scattering processes become advantageous by using them to estimate the quantities of light elements and by combining these data with EDXRF

estimates of the heavier elements, yielding qualitative information representative of the whole specimen. The key to deciphering the x-ray-scattering spectrum lies in the following two facts: (1) larger Compton-scattering signals from specimens that contain lower-atomic-number matrices are stronger due to lower absorption in the specimens, and (2) the ratio of Compton- and Rayleigh-scattering signals (C/R) decreases as the weight-average atomic number of all constituents of the specimen increases (see figure). This weight-average atomic number, is called the atomic scatter factor (ASF). For example, if a specimen is a pure element, then its ASF is simply its atomic number, Z. The ASF of a compound or mixture is calculated through an x-ray-scatter algorithm.

In preparation for quantitative analysis of unknown specimens, one first performs EDXRF and x-ray-scattering measurements on reference specimens of known composition — that is, reference



The **Calibration Curve of the X-Ray-Scatter Algorithm** shows the relationship between the C/R and the ASF. Values for specimens of iron and common corrosion products of iron are shown.

specimens that contain known proportions of elements that are expected to be present in the unknown specimens. The net fluorescence intensity, the C/R, the standard deviation, and the ASF of each reference specimen are computed. Once the library of these references is complete, one can process the x-ray-scattering measurements from an unknown specimen into an estimate of its composition.

The net fluorescence and scattering intensities, I_i, of an unknown specimen are calculated. Then the unknown specimen is compared with each reference specimen by computing a statistic, t_s, as follows:

$$t_s = \sum_{i=1}^{N} \frac{(I_{ix} - I_{ik})^2}{\sigma^2(I_{ix}) + \sigma^2(I_{ik})}$$

where I_{ix} and I_{ik} are the net fluorescence intensities of the ith element of the unknown specimen and the kth reference specimen, respectively; (I_{ix}) and (I_{ik}) are the standard deviations of these intensities; and N is the number of intensities measured. The statistic t_s is a squared Euclidean distance, in an abstract intensity space, between the unknown specimen and the kth reference specimen, weighted with the variances of measured intensities.

After computing t_s with respect to each reference specimen, the algorithm selects the reference for which t_s is the smallest. If the smallest t_s is greater than 90 percent of threshold, the second smallest t_s is also retrieved, and names of both references are displayed along with the message, "possible fit." However, both t_s's must also be less than the 99.9-percent confidence-level threshold. Otherwise, the algorithm determines that none of the references matches the specimen and displays, "no match found."

This work was done by H. Richard Ross of Sverdrup Technology, Inc., for **Stennis Space Center**. *For further information,* ***write in 74*** *on the TSP Request Card. SSC-00015*

Mg_2Si as Li-Intercalation Host for Li Cells

Mg_2Si can reversibly store large amounts of Li and resists attack by organic electrolytes.

NASA's Jet Propulsion Laboratory, Pasadena, California

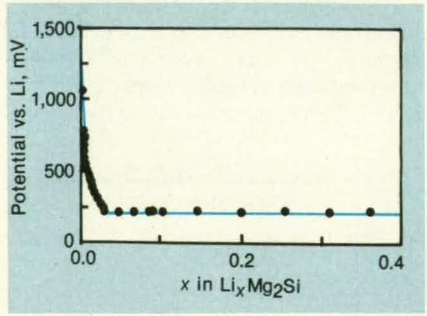
The compound Mg_2Si shows promise as a lithium-intercalation host for ambient-temperature rechargeable lithium electrochemical cells. As anode reactant material, Li_xMg_2Si is chemically stable in the presence of the organic electrolyte used in such cells and can store large amounts of lithium. The intercalation reactions (Li flowing into or out of the interstices of the Li_xMg_2Si crystalline lattice during discharge or charge, respectively) are highly reversible at room temperature. In addition, Li_xMg_2Si retains sufficient mechanical strength during charge/discharge cycling. Lithium cells that contain Li_xMg_2Si anodes may prove useful in spacecraft, military, communications, automotive, and other applications in which the high energy-storage densities of lithium cells in general and the rechargeability of these cells in particular are needed.

Heretofore, the utility of ambient-temperature secondary lithium cells has been limited by their poor cycle-life performance and by a potentially dangerous tendency toward excessive venting. Both of these disadvantages are believed to be associated with the use of pure lithium as the anode material. Freshly deposited lithium is highly chemically active and reacts with most inorganic and organic electrolytes; this results in lower lithium-cycling efficiency. Prolonged cycling of secondary lithium cells produces large quantities of finely divided lithium, making the cells potentially unsafe. Secondary lithium cells have been observed to vent after extended cycling, cycled cells have vented during storage, and cells have vented after being subjected to overcharge followed by overdischarge.

The formation of finely divided dendritic lithium and the degradation of the electrolyte through direct reaction with the lithium can be alleviated or reduced by the use of an alternative anode material that contains lithium and undergoes displacement or insertion (e.g., intercalation) reactions at lithium activities less than unity; although this reduces the specific energy of the cell, there can be a tradeoff if the use of the alternative material enhances the cycle life, performance, and safety of the cell. The current state-of-the-art alternative anode materials are LiC_6, which has poor charge-retention ability, and LiAl, which has poor mechanical strength during charge/discharge cycling.

The electrochemical properties of Li_xMg_2Si were studied by use of three-electrode cells: (–)Li/1M $LiAsF_6$ in 10 percent ethylene carbonate and 90 percent 2-methyltetrahydrofuran/Li_xMg_2Si(+), each with a pure lithium reference electrode. The results of discharge experiments on cells that initially contained Mg_2Si showed that each mole of Mg_2Si was able to react with and absorb up to 1 mole of lithium. The eventual product of this intercalation reaction is a new single phase of the nominal composition $LiMg_2Si$. A comparison of powder-x-ray diffraction tests of $LiMg_2Si$ and Mg_2Si indicate that Mg_2Si accommodates the interstitial addition of lithium atoms without major rearrangement of its crystalline structure.

The figure shows a typical discharge curve of Li intercalating into Mg_2Si at a constant current of 50 μA. The curve shows one plateau region at about 220 mV vs. Li (open-circuit potential). This potential is lower than those of the Li/C system (about 400 mV) and the Li/Al system (386 mV); consequently, the loss of specific energy of the cell would be correspondingly smaller.



The **Intercalation of Li Into Mg_2Si** at 50 μA accompanied by an initial decrease in potential followed by a plateau.

This work was done by Chen-Kuo Huang, Subbarao Surampudi, Alan Attia, and Gerald Halpert of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 83*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquires concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office_JPL [see page 22]. Refer to NPO-18580.

Preventing Growth of Barnacles on Propellers

Mold-release or other coating materials prevent or impede the attachment of barnacles.

Langley Research Center, Hampton, Virginia

An experiment has shown that it should be possible to prevent barnacles and other marine life from obtaining firm bonds on propellers and other metal parts by coating the parts with NEDOX (or equivalent) cavitation-resistant material. NEDOX, made by the General Magnaplate Corp. is available in several forms; the one that would probably work best is a mold-release coating.

Barnacles can form on the propeller of a boat even when the rest of the boat is protected by paint. At present, barnacles are removed from the propeller by scraping; for this purpose, it is necessary either to remove the boat from the water or else to have a diver work underwater.

In the experiment that demonstrated the proposed antibarnacle treatment, uncoated specimens and specimens coated as proposed were placed in the water for several months during the height of the barnacle season. There were no signs of attachment of barnacles to the coated samples, but barnacles did become attached to the uncoated samples.

In addition to providing resistance to barnacles, the proposed coating would also provide improved surface hardness, protection against electrolysis, better resistance to abrasion, and less friction between propellers and water.

This work was done by Kemp L. Parrish of **Langley Research Center**. *No further documentation is available.* *LAR-14759*

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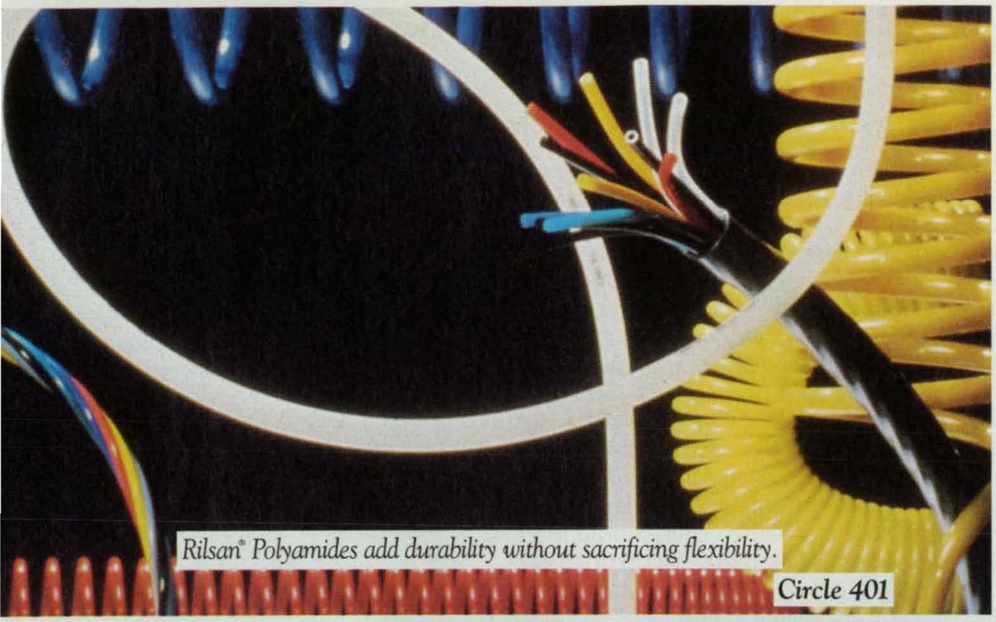

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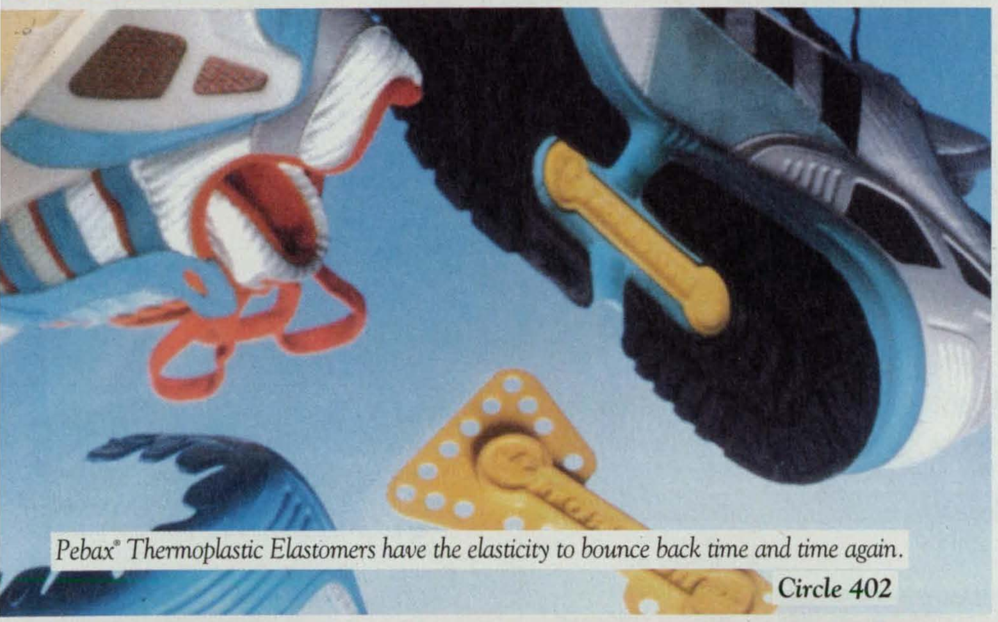

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ATO

Gelled Electrolytes for Lithium Batteries

Thin films of a gelled polymer electrolyte have room-temperature conductivities approaching 10^{-3} S/cm.

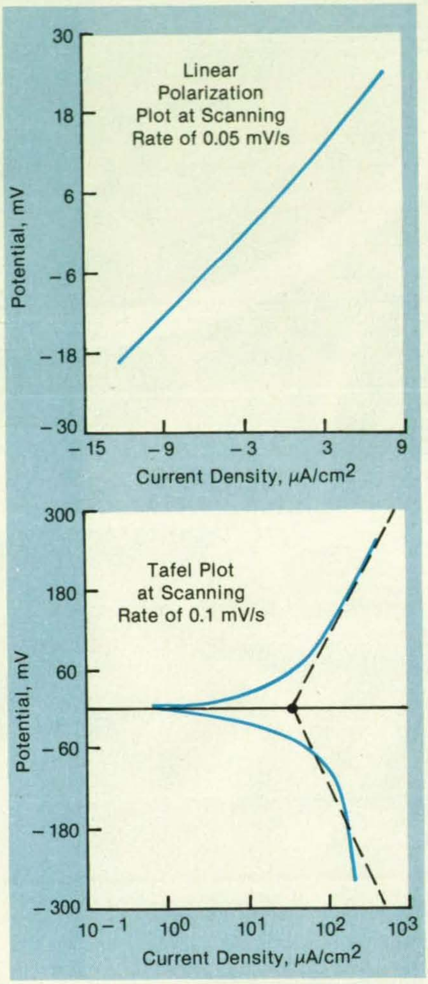
NASA's Jet Propulsion Laboratory, Pasadena, California

A so-called "gelled polymer electrolyte" consists of polyacrylonitrile (PAN), $LiBF_4$, and propylene carbonate (PC). In experiments, thin films of this electrolyte were found to exhibit stable bulk conductivities of the order of 10^{-3} S/cm at room temperature. Usually, ionically conducting polymer electrolytes have very low room-temperature conductivities (about 10^{-7} S/cm), and hence function as electrolytes only at higher temperatures (around 100 °C). Exposure to such temperatures causes degradation of the polymers and eventual degradation of the performances of the electrochemical cells that contain them. The new electrolyte could be used in thin-film, rechargeable lithium batteries that have energy densities near 150 W•h/kg.

The procedure for casting the electrolyte films for the experiments involved the following steps: Appropriate amounts of electrolyte components (2.9 g of PAN, 1.87 g of $LiBF_4$, and 15.06 g of PC) were mixed in a glass beaker inside an argon-filled glove box. The mixture was then slowly heated to 120 °C with constant stirring. The resulting clear pale yellow solution was quickly transferred to polytetrafluoroethylene molds that had been weighed empty. The fluid solidified quickly, and the molds were weighed again. Then the filled molds were transferred to a vacuum oven where they were held for 24 h. The filled molds were then weighed again, and the final composition of the electrolyte films in the molds was computed from the weights and found to be 9.13 weight percent PAN, 6 weight percent $LiBF_4$, and 84.87 weight percent PC. The thickness of the electrolyte films was about 100 μm.

Measurements of the ac impedances of cells of structure Li/electrolyte film/Li showed that the bulk resistivity of the electrolyte is 1,000 to 1,200 Ω•cm, which is comparable to that of liquid electrolytes. The interfacial charge-transfer resistivity was found, from these measurements, to vary initially and reaches a stable value of approximately 1,000 Ω/cm². The double-layer capacitance of a cell was found to be 3 μF.

Cells were subjected to dc polarization measurements, from which linear polarization and Tafel plots (see figure) were constructed. The interfacial charge-transfer resistivities computed from these measurements were close to the values obtained from the ac measurements. Galvanostatic measurements at short times yielded similar results. Tafel slopes for both polarities had similar values; this suggests a facile reversible transfer of Li^+ at the interfaces. The exchange-current density for Li was found to be 0.05 mA/cm². Potentiostatic and galvanostatic measurements in unsymmetrical cells of stainless steel/electrolyte film/Li indicated that the plating/stripping efficiency of Li is about 90 percent. The gelled electrolyte was found to be electrochemically stable for at least 172 hours, after which the experiment was terminated.



The **Dc Polarization Measurements** of symmetrical Li/electrolyte film/Li cells yielded linear polarization and Tafel plots like these.

This work was done by Ganesan Nagasubramanian, Alan Attia, and Gerald Halpert of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 73*** *on the TSP Request Card. NPO-18581*

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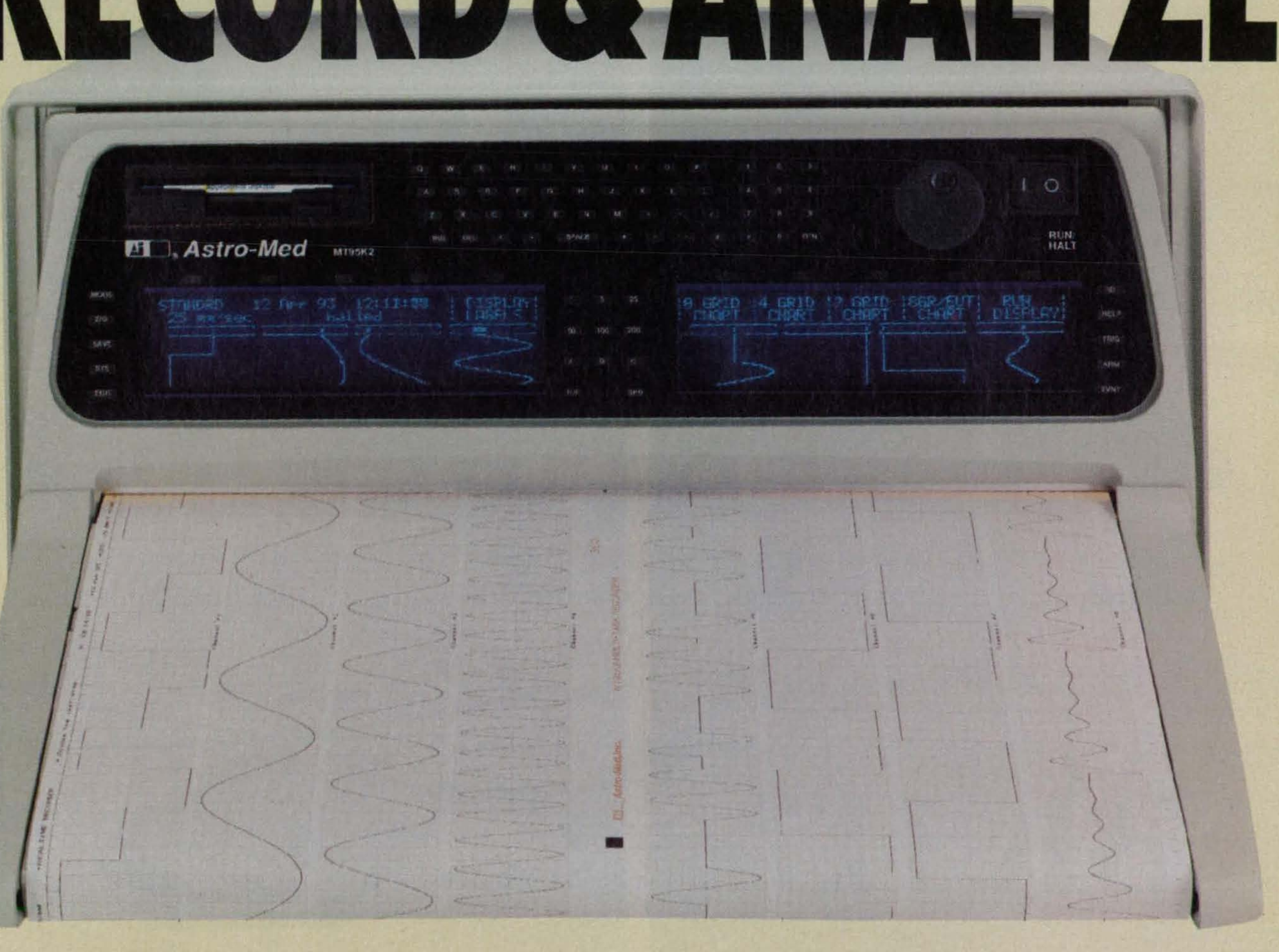

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General-Purpose Element-Extracting Process

Electronically enhanced sputtering would decompose any ore into its constituent elements.

Marshall Space Flight Center, Alabama

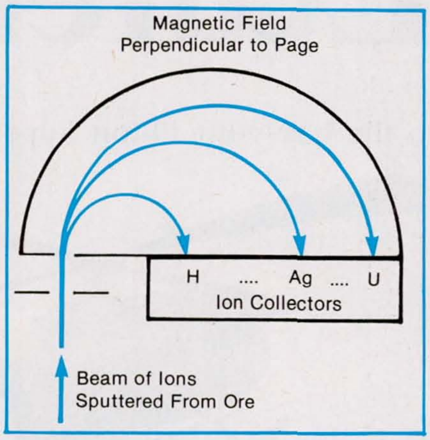
A proposed ore-refining or element-extracting process would be nonspecific: it would decompose any ore or other raw material into its constituent elements, regardless of its composition. The process was conceived to provide the materials for a self-sufficient lunar base from such local ores as anorthite, ilmenite, and olivine. Some version of the process might prove useful on Earth in the recovery or extraction of scarce, valuable, or hazardous materials.

The process would enable the conversion of ores into elements (e.g., metals and liquefied gases) and, further, the recombination of the elements into useful materials as necessary (e.g., alloys, semiconductors, thin films). The process could be effected on a small scale to supplement such other mineral-refining processes as fluidized-bed reduction or carbochlorination. Alternatively, the process could be effected on a large scale to produce a wide range of materials.

Usually, a refining process is designed to remove specific elements from a specific class of ore. However, the proposed process would require no prior knowledge of the composition or crystal structure of the ore or other raw material. The first step of the process would be disintegration, in which the raw material would be broken into its constituent elements by a beam of charged elemental ions. The ions would be accelerated to a kinetic energy at which the interaction between them and the lattice electrons in the ore would be at maximum; this subprocess is known as electronically enhanced sputtering. Experiments have shown that the maximum disintegration of the raw material occurs at an ion kinetic energy of about 5 MeV, regardless of the composition and structure of the raw material. At this energy, for example, each ion in a beam of fluorine ions disintegrates about 8 uranium fluoride molecules, 1,400 ice molecules, or 7,000 sulfur dioxide molecules.

The ions from the disintegrated ore would be driven by an electrical field into a discriminator in the form of a mass spectrometer, where a magnetic field would divert the ions into collectors along trajectories, the radii of which would be proportional to the masses of the ions (assuming that all are singly ionized), thereby separating the ions by species (see figure).

Each collector could consist of an ion trap with a temperature-controlled substrate with a crystalline structure similar to that of crystals of the element to be collected. A layer of the element would be deposited on the substrate. If the deposited element is meant to be collected as a cryogenic liquid, then it would be pumped continuously from the collector into an insulated pressurized storage tank.



A Mass Spectrometer Would Separate Sputtered Ions by elements. Ion collectors would be positioned to intercept the various elements. For a sputtered-ion-accelerating potential of 10,000 V and a magnetic field of 200 G, the helium collector would be located about 70 cm from the hydrogen collector, while the uranium collector would be located about 10 m from the hydrogen collector.

If compounds or alloys were required, the collected ions, instead of being deposited or condensed, could be directed through a focusing mass spectrometer to a substrate where they would be deposited, along with ions of other species, to form superlattices or other crystalline structures containing atoms and molecules in advanced microstructural combinations. Gallium arsenide crystals can be formed in this way, for example.

The process would require a vacuum with a residual pressure of about 10^{-7} torr or less ($\leq 10^{-5}$ Pa). In the original intended lunar application, vacuum chambers would not be necessary, and electrical power could be provided by a solar or nuclear powerplant.

This work was done by Peter A. Curreri of **Marshall Space Flight Center**. *For further information,* ***write in 82*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 22]. Refer to MFS-28541

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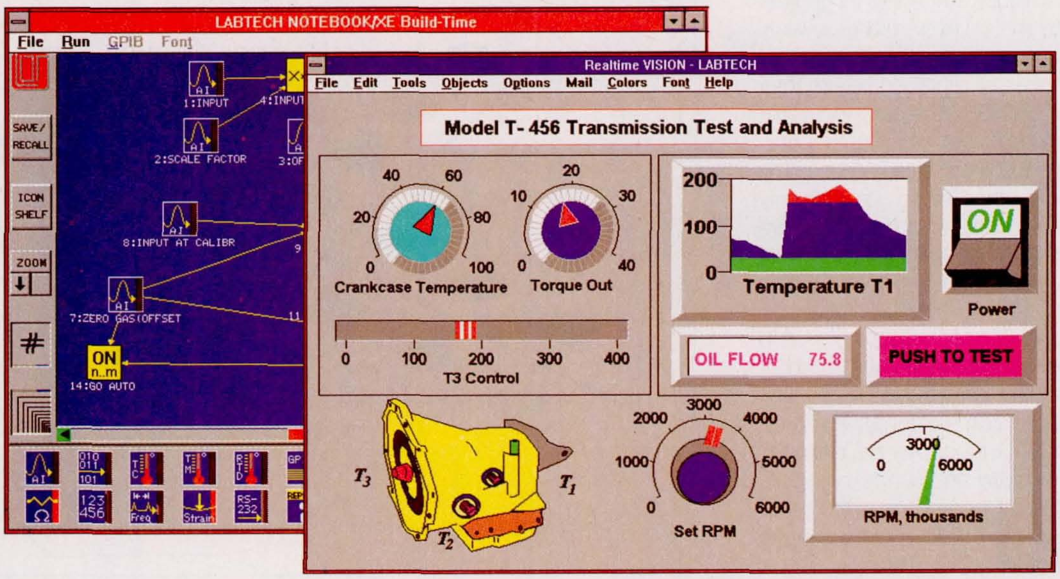

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For More Information Write In No. 430

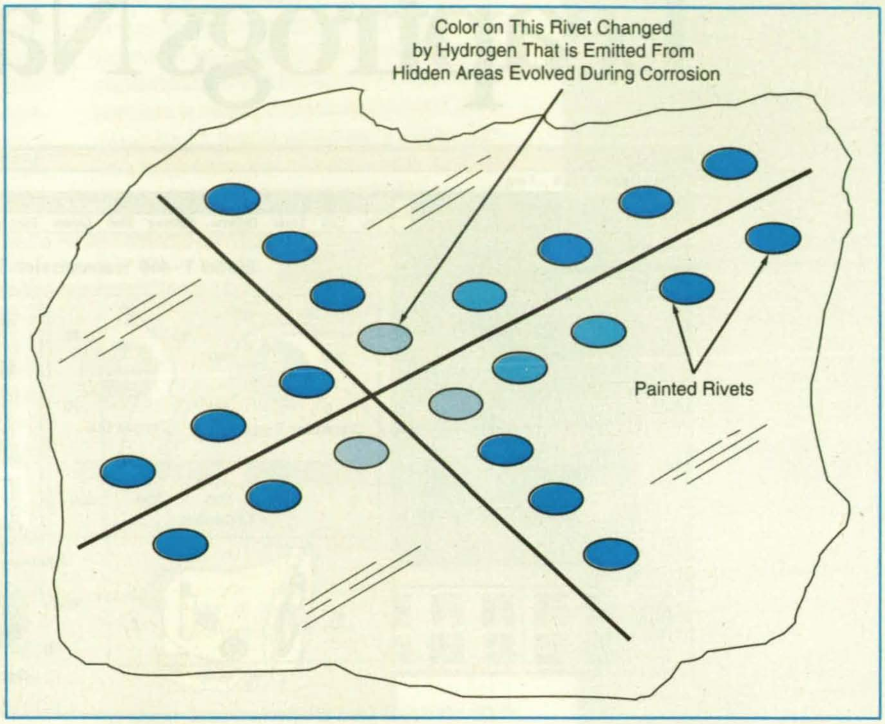
Corrosion-Indicating Pigment and Probes

Hydrogen that evolves during corrosion would cause a change in color.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed hydrogen-sensitive paint for metal structures would change color at the onset of corrosion, which involves emission of hydrogen as a result of electrochemical reactions. As a coating on critical parts of such structures as bridges and aircraft, the paint would give early warning of corrosion, and the parts could thus be repaired or replaced before they failed catastrophically. The paint would reveal corrosion long before it would otherwise become visible to the eye. Inspection for changes in color would not ordinarily necessitate removal of the structure from service, and it would cost less than does inspection by x-ray or thermal neutron radiography, ultrasonic, eddy-current, or acoustic-emission techniques.

The pigment of a suitable paint would include the rhodium compound $RhCl(PPh_3)_3$, known as Wilkinson's catalyst. In monomer form, the compound is red, although it can dimerize to an orange halogen-based species. When exposed to hydrogen, it quickly turns yellow, forming a cis-dihydriorhodium (III) complex.



Painted Rivets Would Change from red or orange to bright yellow when hydrogen evolved from the surrounding metal and hidden areas during corrosion.

The paint would be applied to critical parts of a structure, like rivets on an airplane (see figure). Alternatively, the $RhCl(PPh_3)_3$ could be dissolved in benzene and sprayed on a wider area to indicate underlying corrosion.

Three electrochemical-probe techniques of in situ, nondestructive monitoring for early signs of corrosion have also been proposed. In one of these techniques, a metal probe of high reduction potential (typically, a noble metal) would be moistened with a noncorrosive salt solution and scanned across areas suspected of corrosion. Where the underlying base metal was exposed because corrosion had ruptured its protective coat, a significant voltage would be established between the probe and the underlying metal. The second of these techniques would involve the use of ion-selective electrodes, which can give quantitative data on the extent of corrosion. The third technique involves the use of an ac impedance probe; the progress of corrosion would be measurable in terms of a gradual decrease in impedance.

This work was done by Yoseph Bar-Cohen, Ratnakumar V. Bugga, and Alan I. Attia of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 15*** *on the TSP Request Card.* NPO-18730

Alloys for Corrosive, Hydrogen-Rich Environments

Composition was tailored to provide strength and ductility.

Marshall Space Flight Center, Alabama

"NASA-23" denotes a class of alloys that resist both embrittlement by hydrogen and corrosion. These alloys are weldable and castable and can be formed by such standard processes as rolling, forging, and wire drawing. They can be heat-treated (with alternative heat treatments for wrought and cast forms) to obtain desired combinations of strength and ductility in the ranges of 100 to 180 kpsi (0.69 to 1.24 GPa) yield strength, 120 to 200 kpsi (0.83 to 1.38 GPa) ultimate tensile strength, and 10 to 30 percent elongation at break. The alloys can be used in place of the most common aerospace structural alloy, Inconel* 718, which is severely embrittled in hydrogen.

The starting point for the development of NASA-23 was Incoloy* 903, which resists embrittlement by hydrogen but has poor resistance to corrosion. Chromium was added to impart resistance to corrosion, and such hardening elements as titanium, aluminum, and niobium were added for strength. The contents of the alloys were optimized to give the best properties in high-pressure hydrogen, without need for hydrogen-barrier coatings. The range of compositions, in weight percentages, is as follows: Fe, 35 to 39; Ni, 30 to 34; Co, 14 to 16; Cr, 9 to 11; Nb, 2.5 to 3.5; Ti, 2 to 3; Al, 0.1 to 0.2; C, 0.04 maximum; S, 0.005 maximum; and P, 0.005 maximum.

*"Inconel" and "Incoloy" are registered trademarks of the INCO family of companies.

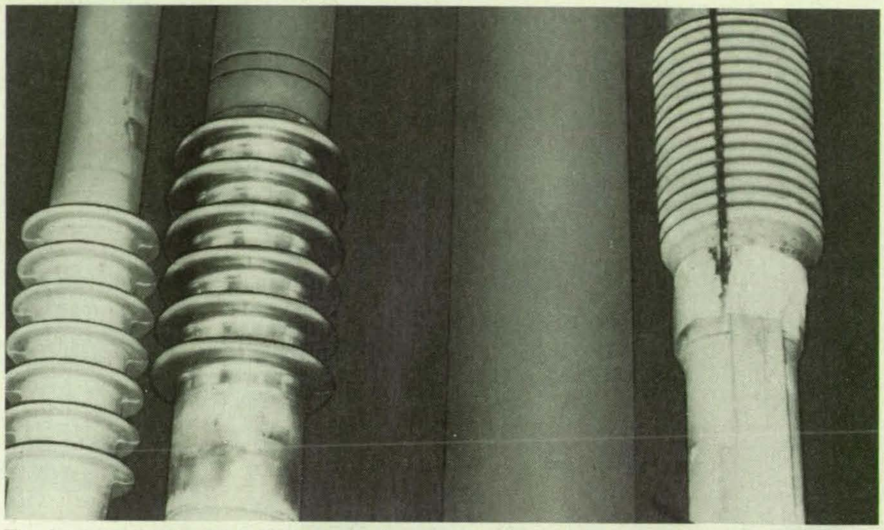
This work was done by William B. McPherson and Biliyar N. Bhat of **Marshall Space Flight Center** *and Po-Shou Chen, A. K. Kuruvilla, and Binayak Panda of IIT Research Institute. For further information,* ***write in 46*** *on the TSP Request Card.* MFS-26200

Clamshell Thermal-Expansion Bellows

Improved design reduces corrosion and allows field installation.

John F. Kennedy Space Center, Florida

An improved bellows serves as a thermal-expansion joint in a vacuum-jacketed cryogenic piping system. The new bellows (see figure) is made of Hastelloy C-22, a nickel-base alloy, and is fabricated in the field by welding two clamshell-like half bellows. It replaces a stainless steel bellows that was coated for protection against corrosion and that nevertheless corroded in an environment containing salt spray and hydrochloric acid. The rate of corrosion of Hastelloy C-22 was found to be only $\frac{1}{47}$ that of 304L stainless steel with no tendency toward pitting errosion. Therefore, no protective paint or maintenance is needed on the new bellows.



The **Improved Clamshell Bellows** is shown on the left, while a defective existing bellows (stainless steel) is on the right.

Defective existing bellows can be cut away from the outer (vacuum-jacket) pipe with a grinding wheel, but without having to cut the inner (cryogenic) pipe. The clamshell halves of the replacement bellows are then put together and welded in place on the outer pipe with longitudinal seam welds. Finally, the ends of the new bellows are welded to the stainless steel outer pipe.

Two versions of the improved bellows have been made of Hastelloy sheet 0.025 in. (0.64 mm) thick: one with a diameter of 2.5 in. (6.4 cm) and length of 11.5 in. (29 cm), the other with a diameter of 3.5 in. (8.9 cm) and length of 13.5 in. (34 cm). In each, convolutions are spaced 1 in. (2.54 cm) apart so that the mating edges can be conveniently welded together. The clamshell bellows design may be modified to fit most thin-wall bellows applications in cryogenic piping systems.

This work was done by J. Fesmire, W. I. Moore, and S. D. DiPasquale of **Kennedy Space Center**. *For further information,* ***write in 13*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center [see page 22]. Refer to KSC-11504

Laboratory Powder Metallurgy Makes Tough Aluminum Sheet

Aluminum alloy sheet exhibits high tensile and Kahn tear strengths.

Langley Research Center, Hampton, Virginia

Rapid solidification of aluminum alloys in powder form and subsequent consolidation and fabrication processes can be used to tailor parts made of these alloys to satisfy such specific aerospace design requirements as high strength and toughness. Previous research at the NASA Langley Research Center showed that it is possible to produce sheet of aluminum 2124 plus 0.6 percent Zr by powder metallurgy on a laboratory scale. The sheet thus produced had the strength of commercial, pilot-scale sheet of the same alloy but lacked the Kahn tear toughness of the pilot-scale sheet.

Therefore, the program was continued with the objective of producing tough aluminum sheet by powder metallurgy. The vacuum hot press used previously for consolidation of the powder was modified to give improved gas conductance, and freshly atomized powder, similar to 2124 alloy with an added 0.9 percent Zr, was used. In this research, a tough, strong aluminum sheet was produced by powder metallurgy on a laboratory scale and evaluated in the fully hardened T8 temper.

The powder was consolidated in two main steps. In the first step, a precursor billet strong enough for handling was formed by cold isostatic pressing. The precursor billet was loaded into the vacuum hot press for second-step processing. The vacuum-hot-pressing cycle consisted of hot vacuum degassing at a temperature of 500°C followed by hot pressing at a pressure of 50 MPa to full or nearly full density while still under vacuum.

A commercial, heated-platen, 890-kN hydraulic press was used to forge the cylindrical vacuum-hot-pressed billet to a rectangular-cross-section ingot used for rolling to sheet. A commercial, dc-drive, two-high rolling mill was used to roll the forged ingot to sheet 10 cm wide. Thermal treatments were performed in an air-recirculating furnace. Stretching was accomplished in a hydraulic mechanical testing machine with both load and ram-movement control. The rolled sheet was then laid out for metallurgical specimens, subsize-tensile-specimen blanks according to specifications of the American Society for Testing and Materials, and Kahn-tear-specimen blanks. The blanks were machined to specimens with "as-rolled" surfaces.

The sheet was evaluated in both the L and L–T directions and exhibited a significantly improved combination of strength and toughness over that of the previous research. In both directions, the sheet was strong (yield strength 465 to 490 MPa) and tough (Kahn tear unit-propagation-energy values over three times those typical for ingot-metallurgy 2024-T81). Adequate toughness was also evidenced by the attainment of Kahn-tear-strength-to-yield-strength ratios of 1.2 in the L–T direction and 1.2 to 1.4 in the T–L direction. These results indicate that, with fresh powder and a good degassing treatment before vacuum consolidation, it is indeed possible to produce tough, strong aluminum sheet by powder metallurgy in the laboratory.

This work was done by D. M. Royster and J. R. Thomas of **Langley Research Center** *and O. R. Singleton of Singleton Technology, Inc. For further information,* ***write in 20*** *on the TSP Request Card.* *LAR-14599*

World Aerospace Leaders

Profiles of Pathsetters in the Aerospace/Defense Industry

Pierre de Bayser

Executive Director, Alcatel Space Division

BACKGROUND:

Born in 1943, Pierre de Bayser graduated from the French Ecole Superieure D'Electricite in 1968. He then began his nonstop involvement in the space arena by joining Thomson CSF's microwave laboratory. After managing the lab from 1972 to 1979, he was appointed Head of the Technical Division of Thomson CSF's Space and Satellite Division.

In 1981, Mr. de Bayser became Assistant Director for Technical and Equipment Production in the Space Division of Thomson CSF, which subsequently was transferred to Alcatel Espace. Four years later, he switched to Assistant Director of the Programs and Sales Division and Director of the Sales and Onboard Systems Department.

Since 1990, he has managed the Alcatel Group's Space Division.

COMPANY PROFILE:

Alcatel Espace is a world leader in space communications systems and complete payloads, with over 30 years expertise. Alcatel specializes in communications links between the Earth and all types of spacecraft, of telemetry/telecommand of satellites and deep space probes such as the French Spot satellite and the European Ulysses and Giotto experiments. Alcatel used its expertise in microwave technology to develop spaceborne radars that have operated successfully on ERS-1 and Topex Poseidon remote sensing satellites.

Alcatel Espace is the leading company of Alcatel's Space Division, which relies on the experience of 2200 specialists in space techniques working in eight companies operating in six European countries.

Jean-Francois Bigay

Chairman and Chief Executive Officer, Eurocopter S.A.

BACKGROUND:

Mr. Bigay was born in Chamalières, France in 1943 and graduated from the French Ecole Nationale de l'Aéronautique in 1967, when he joined Nord Aviation as a design engineer. Three years later, he became Production Engineer, then Production Deputy for Aerospatiale's Space and Strategic Systems Division, with direct responsibilities for the development and industrialization of the Ariane rocket launcher.

In 1979, he joined the Avions Hurel Dubois Company, where he successfully installed the composites technology and developed the thrust reverser business for the F200, F900, and A320 aircraft. After serving as General Manager at Roux Combaluzier Schindler from 1984 to 1986, he became General Manager of the Marignane Plant for Aerospatiale's Helicopter Division. With the creation of Eurocopter S.A. in January, 1992, he became Chairman and CEO of the new Franco-German venture.

Mr. Bigay was elected a Member of the Board of GIFAS, the French Aerospace Industry Association, this past July.

COMPANY PROFILE:

Eurocopter S.A., a subsidiary of Aerospatiale (70% ownership) and Deutsche Aerospace (30% ownership), is the leading company of the Eurocopter Group, the world's second largest producer of helicopters and the leader in the civil market with a 52% market share in 1992. Its sales reached the $2 billion mark last year.

With 12,000 employees worldwide and ten foreign subsidiaries, Eurocopter provides the widest range of civil and military helicopters — from 2.5 to 9.5 tons. New product developments and technology breakthroughs, as well as world records, are part of the company's history, and based on Aerospatiale's and MBB's 30+ years of experience in the helicopter business.

Louis Gallois

Chairman and Chief Executive Officer
Aerospatiale

BACKGROUND:

Born in Montauban (Tarn et Garonne, France) on January 26, 1944, Mr. Gallois began his career in 1972 as a Public Administrator in the Treasury Department of the Ministry of Economy and Finance. He served as Financial Attaché for Asia from 1976 to 1978, when he became Head of the Aid to the Economic Development Bureau. He next headed the Cabinet Office of the Research & Technology Ministry, followed by a post as General Director for Industry in the Ministry of Industry.

In 1988, Mr. Gallois joined the French Defense Ministry as Head of the Civil and Military Cabinet Office, and the following year became Chairman and Chief Executive Officer of SNECMA (Société Nationale d'Etudes et de Constructions de Moteurs d'Avions). Last year, he was named Chairman and Chief Executive Officer of Aerospatiale.

Mr. Gallois is Vice President of GIFAS, the French Aerospace Industry Association, and a board member of Dassault Aviation, of the Ecole Polytechnique, and of the Ecole Centrale des Arts et Manufactures.

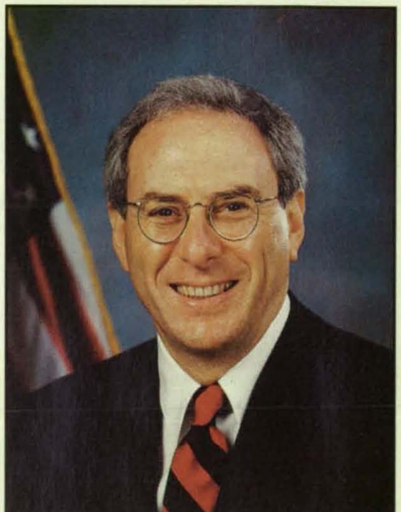
COMPANY PROFILE:

Aerospatiale is one of the world's leading aerospace manufacturers. Its products include civil and military aircraft and helicopters, missiles, launch vehicles, and satellites for scientific exploration and space applications.

Known especially for its participation in the Airbus, ATR, and Concorde programs, Aerospatiale is Europe's leading manufacturer of commercial airliners, is second worldwide in helicopter production, and is the European leader for satellite exports and missile production. Further, the company is industrial architect for the Ariane launcher.

Daniel S. Goldin

Administrator
National Aeronautics & Space Administration



BACKGROUND:

Daniel Goldin became the ninth NASA Administrator on April 1, 1992. Prior to his nomination, he was Vice President and General Manager of the TRW Space & Technology Group in Redondo Beach, CA, where he managed the development of advanced spacecraft, technologies, and space science instruments.

Born in New York City in 1940, Mr. Goldin began his career as a research scientist at NASA's Lewis Research Center from 1962 to 1967. While there, he worked on electric propulsion systems for human interplanetary travel. He joined TRW in 1967 as a member of the technical staff. During his tenure as Vice President and General Manager, Mr. Goldin pioneered such advanced technologies as superconductivity, composites, and electro-optics, and built 13 spacecraft that continue to operate successfully in orbit. These include NASA's Tracking and Data Relay Satellite-5 and the Compton Gamma Ray Observatory. The group also worked on the successful grinding and testing of the world's two largest x-ray mirrors, for the Advanced X-Ray Astrophysics Facility.

Prior to that position, Mr. Goldin managed several advanced technology programs of high national priority. He led TRW's efforts to design, develop, and produce the U.S. Air Force's MILSTAR communications satellite and managed the direct broadcast payload for NASA's communications technology that became the forerunner of current direct broadcast television systems. He also has held leadership positions on several NASA studies for interplanetary, asteroid-flyby, and comet rendezvous missions.

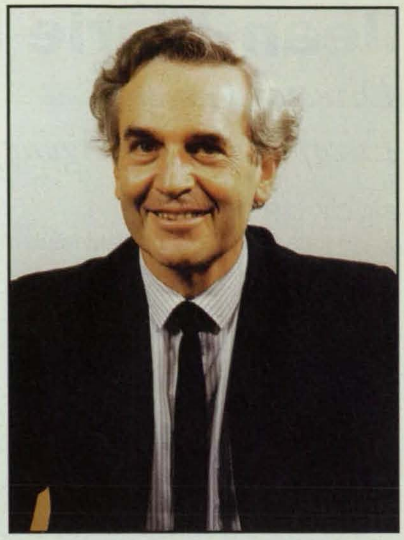
AGENCY PROFILE:

NASA was established by the National Aeronautics and Space Act of 1958 to direct, plan, and conduct aeronautical and space activities for peaceful purposes that benefit all mankind. NASA's goals in space are to develop technology to make operations more effective, to enlarge the range of practical applications of space technology, and to investigate the Earth and its immediate surroundings, the natural bodies in our solar system, and the origins and physical processes of the universe. In aeronautics, NASA seeks to improve aerodynamics, structures, engines, and overall performance of aircraft.

The agency's major programs include the space shuttle, space station Freedom, the National Aero-Space Plane, High-Speed Civil Transport, the Earth Observing System, and an array of scientific satellites and planetary probes.

Jean-Claude Husson

Managing Director
Alcatel Espace



BACKGROUND:

Born in 1937, Mr. Husson graduated from the Ecole Polytechnique and the Ecole d'Application des Officiers de Marine et du Service Hydrographique de la Marine. After spending seven years as a hydrographer in the French Navy, he joined CNES, France's national space agency, in 1966 and remained there until 1986. From 1975 onward, he was a member of the Executive Committee, and also served as General Manager of the CNES Space Center in Toulouse. Mr. Husson was successfully in charge of the French space geodetics program, scientific space programs, and medium- and long-term budget planning. An expert in space techniques and technology, he participated in all space projects undertaken by France, both on its own and in cooperation with NASA, ESA, and INTERCOSMOS.

In 1986, he was appointed General Manager of IFREMER, an organization charged with the exploitation of ocean resources, where he spent several months laying the foundation of future oceanography using satellites and underwater robotic devices. He joined the Alcatel Group in September, 1986 and the next month was named President and Chief Operating Officer of Alcatel Espace. He also is Chairman of the Alcatel Space Division, a part of Alcatel N.V. bringing together Alcatel Espace (France), Alcatel Bell and ETCA (Belgium), Alcatel Espacio (Spain), Alcatel Denmark, and Ame Space (Norway).

COMPANY PROFILE:

Alcatel Espace is a world leader in space communications systems and complete payloads, with over 30 years expertise. Alcatel specializes in communications links between the Earth and all types of spacecraft, of telemetry/command of satellites and deep space probes such as the French Spot Satellite and the European Ulysses and Giotto experiments. Alcatel used its expertise in microwave technology to develop spaceborne radars that have operated successfully on ERS-1 and Topex Poseidon remote sensing satellites.

Alcatel Espace is the leading company of Alcatel's Space Division, which relies on the experience of 2200 specialists in space techniques working in eight companies operating in six European countries.

Jean-Daniel Levi

General Manager
Centre National d'Etudes Spatiales (CNES)

BACKGROUND:

Mr. Levi was born on May 30, 1940 in Marrakech. He is a graduate of the Ecole Polytechnique (1960) and the Ecole Nationale de la Statistique et de l'Administration Economique (1965). From 1965 to 1982, he was an economist at the French Electricity Authority and French Gas Authority. In 1982, he was called upon to join the President of the Republic's Office as Technical Adviser for Energy, Raw Materials, Nuclear, Space, and Aircraft Construction Matters. He also was Permanent Secretary to the Council for Foreign Nuclear Policy.

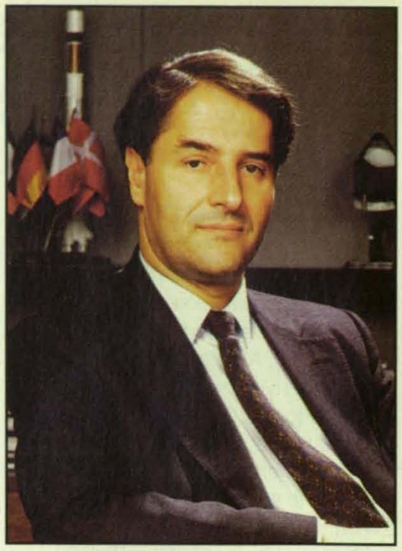
In 1989, he was appointed Director General for Energy and Raw Materials at the Ministry for Industry and National Development. In this capacity, he was a member of the boards of ERAP and PECHINEY, a member of the Atomic Energy Committee, President of the French Raw Materials Fund, and Government Commissioner to COGEMA and the French Agency for Energy Control. He has been General Manager of CNES since October, 1990.

AGENCY PROFILE:

The principal missions of CNES, the French national space agency, are: to participate, as France's representative at the European Space Agency, in the elaboration and execution of European programs (France's contribution to ESA programs accounts for 47% of CNES' budget); to develop scientific and application activities within a national framework (20% of CNES' budget); to design and manage as prime contractor the major projects carried out in industry; to assist in operational missions at Ariane launches, and spacecraft station acquisition and station-keeping through the Guiana Space Center and CNES's network of stations (15% of its budget); to prepare future space programs; and to consolidate and develop the know-how and skills of French industry.

Jean-Marie Luton

Director General
European Space Agency



BACKGROUND:

Born August, 1942 in Chamalières (Puy de Dome), France, Mr. Luton began his career in 1964 as a researcher in external geophysics at the Service d' Aéronomie of the CNRS, the French National Center for Scientific Research. From 1971 to 1973, he acted as "Chargé de Mission" at the Service des Programmes des Organismes de Recherche within the Ministry for Industrial and Scientific Development. In this capacity, he was involved in drawing up the French position on space policy and in the negotiations that led to the establishment of the European Space Agency (ESA) and its programs.

In 1974, he joined CNES, the French space agency, where, within the Programs and Industrial Policy Directorate, he headed the Research Programs Division (1974-1975) and then the Planning and Projects Division (1975-1978). In 1978, he was appointed Director of Programs and Planning, a post he held until 1984 when he became Deputy Director General. Mr. Luton joined Aerospatiale in 1987 as Director for Space Programs, and in 1989 was appointed Director General of CNES. The following year, he was named Director General of ESA.

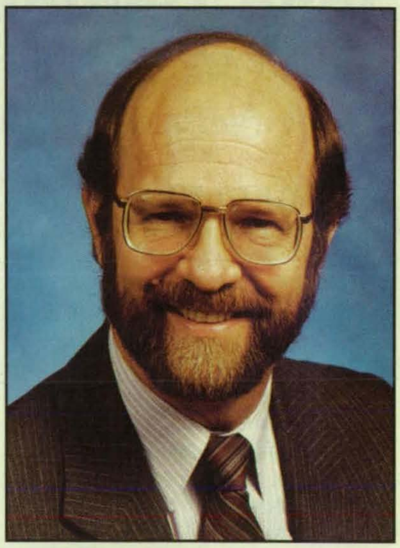
AGENCY PROFILE:

The European Space Agency was formed to promote collaboration among European states in space research and technology (and applications) exclusively for peaceful purposes. It provides scientific agencies of the member countries with the necessary technical facilities to carry out space experiments, ranging from the study of the near terrestrial environment to stellar astronomy. ESA is responsible for a program of applications satellities, including telecommunications and meteorology, and for the Spacelab module and Ariane family of launch vehicles.

The agency maintains the following establishments: the European Space Research and Technology Center, Noordwijk, Netherlands; the European Space Operations Center, Darmstadt, Federal Republic of Germany; the European Space Research Institute, Frascati, Italy; and the European Astronauts Center, Cologne, Germany. Members include Austria, Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, and the UK. Finland is an associate member, while Canada is linked by a special cooperative agreement.

John F. McDonnell

Chairman and
Chief Executive Officer
McDonnell Douglas Corporation



BACKGROUND:

Born in Baltimore, MD, on March 18, 1938, Mr. McDonnell joined McDonnell Aircraft Company soon after he was awarded a master's degree in aeronautical engineering from Princeton University in 1962. He started as a strength engineer and moved into contract administration and corporate finance. In 1968, he was named Vice President of a newly formed subsidiary, McDonnell Douglas Finance Corporation.

Mr. McDonnell returned to corporate headquarters in St. Louis in 1971 as Staff Vice President, Fiscal. The following year, he was named Corporate Vice President for Finance and Planning, and was elected to the corporation's board of directors in 1973. He became Corporate Vice President in 1977 and President in 1980. In 1987, he gained the additional position of Chief Operating Officer, and in 1988 was elected to his current position.

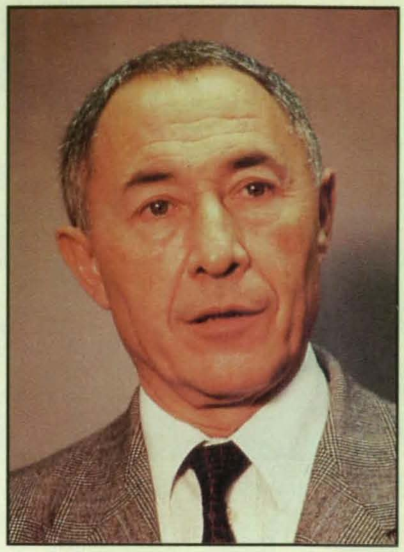
Mr. McDonnell is President of the board of trustees of the St. Louis Science Center. He is on the board of trustees at Washington University.

COMPANY PROFILE:

McDonnell Douglas Corporation is a world leader in the development and application of aerospace technology. McDonnell Douglas' major product lines are combat aircraft, transport aircraft, space systems, missiles, and defense electronics. The corporation also is active in commercial financing and leasing. McDonnell Douglas has approximately 74,000 employees worldwide and had revenues of more than $17.4 billion in 1992.

Rene Pellat

President
Centre National d'Etudes Spatiales (CNES)



BACKGROUND:

Born February 24, 1936 in Alger, Mr. Pellat graduated from the Ecole Polytechnique in 1956 and earned a civil engineering degree from the Ecole des Ponts et Chaussées in 1961. The following year, he joined the Atomic Energy Commission's Department of Plasma and Fusion Physics. He became Research Director at the Centre National de la Research Scientifique (CNRS) in 1972 and continued his theoretical research on controlled thermonuclear fusion and on ionized and gravitational plasmas.

From 1973 to 1982, Mr. Pellat was Assistant Professor at the Ecole Polytechnique and also has taught at the universities of Orsay, Toulouse, and Marseilles. (He presently is Visiting Professor of Physics at UCLA.) From 1983 to 1987, he was Chairman of the Dept. of Earth, Ocean, Atmosphere, and Space, and a member of CNRS' Scientific Council and the High Council on Research and Technology.

He succeeded Claude Frejacques as CNRS' Chairman of the Board in 1981, and later was CNRS' representative on the Board of Administration of INSERM and the Atomic Energy Committee. He served as Scientific Advisor to the Director General of CNES beginning in 1982, and was Chairman of the agency's Scientific Program Committee from 1986 to 1988. In November, 1992, he succeeded Jacques Louis Lions as Chairman of the Board of CNES.

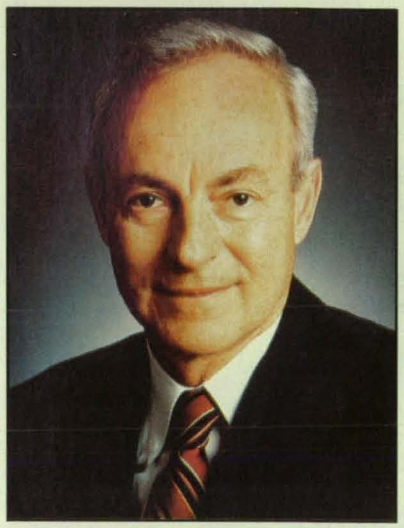
Mr. Pellat is a Knight of the French Order of Merit and an Officer of the Legion of Honor.

AGENCY PROFILE:

The principal missions of CNES, the French national space agency, are: to participate, as France's representative at the European Space Agency, in the elaboration and execution of European programs (France's contribution to ESA programs accounts for 47% of CNES' budget); to develop scientific and application activities within a national framework (20% of CNES' budget); to design and manage as prime contractor the major projects carried out in industry; to assist in operational missions at Ariane launches, and spacecraft station acquisition and station-keeping through the Guiana Space Center and CNES's network of stations (15% of its budget); to prepare future space programs; and to consolidate and develop the know-how and skills of French industry.

Daniel M. Tellep

Chairman of the Board and
Chief Executive Officer, Lockheed Corporation



BACKGROUND:

Daniel Tellep was elected Chairman of the Board and CEO of Lockheed effective January 1, 1989. He accepted that position after serving as President of the corporation since August, 1988. Mr. Tellep, a member of the Board of Directors since 1987, had been Group President of Lockheed Missiles and Space Systems since 1986 and President of Lockheed Missiles and Space Company (LMSC) since 1984. He was elected a Vice President of the corporation in 1983. Mr. Tellep joined LMSC in 1955 as Principal Scientist for the X-17 missile reentry flight experiments. In subsequent years, he managed programs in thermodynamics, missile reentry systems, and engineering development.

Born in Forest City, PA, in 1931, Mr. Tellep graduated with a bachelor's degree in mechanical engineering from the University of California at Berkeley in 1954. He received a master's degree in the same discipline from U.C. Berkeley the following year.

Mr. Tellep serves on the board of the National Aeronautic Association and on the Board of Governors of the Music Center of Los Angeles County. He was elected a fellow of the American Institute of Aeronautics and Astronautics (AIAA) and the American Astronautical Society, and is a member of the National Academy of Engineering. He was awarded the AIAA's Lawrence B. Sperry Award in 1964 and its Missile Systems Award in 1986. He was the 1992 electee of the Society of Manufacturing Engineers and that same year won the American Astronautical Society's Industrial Leadership Award.

COMPANY PROFILE:

Headquarted in Calabasas, CA, Lockheed Corp. ranks as the third largest U.S. Department of Defense contractor and the second largest NASA contractor. The corporation had sales of approximately $10 billion in 1992, before the acquisition of the Lockheed Fort Worth Company, and employs about 90,000 people.

A world leader in defense, electronics, and space systems technology, Lockheed designs and produces military aircraft, satellites, and missiles, and provides a wide range of government and commercial aeronautical, space, environmental, and engineering services.

Lockheed's operating companies and divisions are organized into four major groups: Aeronautical Systems, Missiles and Space Systems, Technology Services, and Electronic Systems.

From telecommunications to space oceanography - Alcatel Espace serving planet Earth.

The oceans play a determining role in the Earth's climatic systems, carrying 50% of the Equator's heat towards the poles. Yet ocean circulation still remains largely unknown. Satellite altimeter observation will help us understand planet Earth better, on both the climatic and ecological levels.

In building a new generation radar altimeter for CNES, the French Space Agency, Alcatel Espace has brought its skills in space electronics to serve ocean observation. The compact, low-power consumption altimeter, with good operational flexibility is called Poseidon.

With the synthetic aperture radar aboard ERS and the radar altimeter launched on Topex-Poseidon, Alcatel Espace confirms its technological advance in the field of space radars dedicated to oceanography.

ALCATEL

ESPACE

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CASTERAN/IMAGE PH

Computer Programs

COSMIC: Transferring NASA Software

COSMIC, NASA'S Computer Software Management and Information Center, distributes software developed with NASA funding to industry, other government agencies and academia.

COSMIC's inventory is updated regularly; new programs are reported in *Tech Briefs*. For additional information on any of the programs described here, circle the appropriate TSP number.

If you don't find a program in this issue that meets your needs, call COSMIC directly for a free review of programs in your area of interest. You can also purchase the annual *COSMIC Software Catalog*, containing descriptions and ordering information for available software.

COSMIC is part of NASA's Technology Transfer Network.

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The University of Georgia, 382 East Broad Street,
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Computer Programs

These programs may be obtained at a very reasonable cost from COSMIC, a facility sponsored by NASA to make computer programs available to the public. For information on program price, size, and availability, circle the reference number on the TSP and COSMIC Request Card in this issue.

Mathematics and Information Sciences

PLOT3D/AMES

An interactive graphics program helps scientists visualize computational fluid dynamics grids and solutions.

Today, supercomputers and Computational Fluid Dynamics (CFD) algorithms can provide scientists with simulations of such complexity that visualization has become mandatory for understanding these simulations. PLOT3D/AMES offers a multitude of functions and features and has been adapted for more types of computers than any other CFD graphics program. PLOT3D is a reliable and versatile program. Version 3.6b+ is supported for five computers and graphic libraries. Using PLOT3D/AMES, CFD scientists can view their computational models from any angle, observing the physics of problems and the quality of solutions.

As an aid in designing aircraft, for example, the interactive computer graphics of this program can show vortices, temperature, reverse flow, pressure, and dozens of other characteristics of airflow during flight. As critical areas become obvious, they can be studied more closely using a finer grid.

PLOT3D/AMES is part of a computational fluid dynamics software cycle. First, a program such as 3DGRAPE (ARC-12620) helps the scientist generate structural computational grids to model an object and its surrounding space. Once the grids have been designed and parameters, such as the angle of attack, mach number, and Reynolds number, have been specified, a "flow-solver" program such as INS3D (ARC-11794 or COS-10019) solves the system of equations governing fluid flow, usually on a supercomputer. Grids sometimes have as many as two million points, and the flow-solver produces a solution file which contains density, *x*-, *y*-, and *z*-momentum, and stagnation energy for each grid point. With such a solution file and a grid file containing up to 50 grids as input, the program can calculate and graphically display any one of 74 functions, including shock waves, surface pressure, velocity vectors, and particle traces.

PLOT3D/AMES 74 functions are organized into five groups: (1) Grid Functions for grids, grid-checking, and the like; (2) Scalar Functions for contour, isosurface or carpet plots of density, pressure, temperature, mach number, vorticity magnitude, helicity, and the like; (3) Vector Functions for vector plots of velocity, vorticity, momentum, density gradient, and the like; (4) Particle Trace Functions for rakelike plots of particle flow or vortex lines; and (5) Shock locations based on pressure gradient.

TURB3D is a modification of PLOT3D/AMES, which is used for viewing CFD simulations of incompressible turbulent fluid flow. Input flow data consists of pressure, velocity, and vorticity. Typical quantities to plot include local fluctuations in flow quantities and turbulent production terms, plotted in physical or wall units. TURB3D is available only as a "bundle" with PLOT3D/AMES because the operation of TURB3D is identical to PLOT3D/AMES and there are no additional sample data or printed documentation for TURB3D.

Graphical capabilities of PLOT3D/AMES version 3.6b+ vary among the implementations available from COSMIC. Users are encouraged to review carefully the PLOT3D/AMES manual before ordering the program for a specific computer and graphics library. There is only one manual for all machine versions, and, although this manual generally assumes that the Silicon Graphics IRIS implementation is being used, informative comments concerning other implementations appear throughout the text. With all machine versions, the visual representation of the object and flow field created by PLOT3D/AMES consists of points, lines, and polygons. Points can be represented with dots or symbols, color can be used to denote data values, and perspective is used to show depth.

Differences among implementations affect the ability of the program to use graphical features that are based on 3-D polygons, the user's ability to manipulate the graphical displays, and the user's ability to obtain hard-copy output.

SGI IRIS Version: In each of the areas mentioned above, the IRIS implementation of PLOT3D/AMES offers advanced features which aid visualization efforts. Shading and hidden-line/surface removal can be used to enhance depth perception and other aspects of the graphical displays. A mouse can be used to translate, rotate, or zoom in on views. Files for several types of output can be produced. Two animation options are offered: (1) creation of simple animation sequences without the need for other software and (2) creation of files for use in GAS (ARC-12379) and FAST (ARC-13316), IRIS programs, which offer more complex rendering and animation capabilities and can record images to digital disk, video tape, or 16-mm film.

The version 3.6b+ SGI implementations of PLOT3D/AMES (ARC-12783) and PLOT3D/TURB3D (ARC-12782) were developed for use in Silicon Graphics IRIS 2xxx/3xxx or IRIS 4D workstations. These programs are each distributed on one 0.25 in. (6.35 mm) magnetic tape cartridge in IRIS TAR format.

UNIX Supercomputer and SGI IRIS Version: In addition to providing the advantages of performing complex calculations on a supercomputer, the Supercomputer/IRIS implementation of PLOT3D/AMES offers advanced 3-D, view manipulation, and animation capabilities. Shading and hidden-line/surface removal can be used to enhance depth perception and other aspects of the graphical displays. A mouse can be used to translate, rotate, or zoom in on views. Files for several types of output can be produced. Two animation options are available. Simple animation sequences can be created on the IRIS, or, if an appropriately modified version of ARCGRAPH (ARC-12350) is accessible on the supercomputer, files can be created for use in GAS (ARC-12379) or FAST (ARC-13316).

The version 3.6b+ Supercomputer/IRIS implementations of PLOT3D/AMES (ARC-12779) and PLOT3D/TURB3D (ARC-12784) are suitable for use on CRAY-2/

UNICOS, CONVEX, and ALLIANT computers with a remote Silicon Graphics IRIS 2xxx/3xxx or IRIS 4D workstation. These programs are distributed on 0.25 in. (6.35 mm) magnetic tape cartridges in IRIS TAR format.

DEC VAX Version Using DISSPLA: The VAX/VMS/DISSPLA implementation of PLOT3D/AMES supports 2-D polygons as well as 2-D and 3-D lines, but does not support graphics features requiring 3-D polygons; e.g., shading and hidden-line removal. Views can be manipulated using keyboard commands. This version of PLOT3D/AMES is potentially able to produce files for a variety of output devices; however, site-specific capabilities will vary depending on the device drivers supplied with the user's DISSPLA library. If ARCGRAPH (ARC-12350) is installed on the user's VAX, the VMS/DISSPLA version of PLOT3D/AMES can also be used to create files for use in GAS or FAST.

The version 3.6b+ VMS/DISSPLA implementations of PLOT3D/AMES (ARC-12777) and PLOT3D/TURB3D (ARC-12781) were developed for use on VAX computers running VMS Version 5.0 and DISSPLA Version 11.0. The standard distribution media for each of these programs is a 9-track, 6250 bits/in. (2.46×10^5 bits/m) magnetic tape in DEC VAX BACKUP format.

Generic UNIX Version Using DISSPLA: The UNIX/DISSPLA implementation of PLOT3D/AMES supports 2-D polygons as well as 2-D and 3-D lines, but does not support graphics features requiring 3-D polygons; e.g., shading and hidden-line removal. Views can be manipulated using keyboard commands. This version of PLOT3D/AMES is potentially able to produce files for a variety of output devices; however, site-specific capabilities will vary depending on the device drivers supplied with the user's DISSPLA library.

The version 3.6b+ UNIX/DISSPLA implementations of PLOT3D/AMES (ARC-12788) and PLOT3D/TURB3D (ARC-12778) were developed for use on computers running UNIX SYSTEM 5 with BSD 4.3 extensions and DISSPLA 11.0. The standard distribution media for each of these programs is a 9-track, 6250 bits/in. (2.46×10^5 bits/m) magnetic tape in TAR format.

Apollo UNIX Version Using GMR3D: The Apollo implementation of PLOT3D/AMES uses some of the capabilities of Apollo's 3-dimensional graphics hardware, but does not take advantage of the shading and hidden-line/surface removal capabilities of the Apollo DN10000. Although this implementation does not offer a capability for putting text on plots, it does support the use of a mouse to translate, rotate, or zoom in on views.

The version 3.6b+ Apollo implementations of PLOT3D/AMES (ARC-12789) and PLOT3D/TURB3D (ARC-12785) were developed for use on Apollo computers running UNIX System V with BSD 4.3 extensions and the graphics library GMR3D Version 2.0. The standard distribution media for each of these programs is a 9-track, 6250 bits/in. (2.46×10^5 bits/m) magnetic tape in TAR format.

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This program was written by Pieter G. Buning of **Ames Research Center**, *with support from Larry Pierce and Pat Elson of Sterling Software and Pamela Walatka of Computer Sciences Corp. For further information,* ***write in 27*** *on the TSP Request Card.*

ARC-12777, ARC-12778, ARC-12779, ARC-12781, ARC-12782, ARC-12783, ARC-12784, ARC-12785, ARC-12788, and ARC-12789.

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NASA TileWorld Simulator Program

NTW aids research on planning, scheduling, and control problems.

The NASA TileWorld (NTW) computer program was formulated to further research on planning, scheduling, and control problems. It is believed that by isolating essential characteristics of problems and studying their effects on the performances of autonomous systems, the process of creating systems that solve practical, real-world problems can be improved. NTW was designed to focus on three particular attributes of real-world problems: exogenous events, uncertain outcomes of actions, and metric time (which is defined below). Although written specifically for use by NASA, NTW can be modified easily to act as a software base for other simulated environments.

NTW implements a simulator mathematical model that consists of a two-dimensional grid of cells populated with movable tiles and a single mobile agent. The agent can grasp tiles that are in directly adjacent cells, release a grasped tile, or move to an adjacent cell. The agent can also sense its location, determine whether it is grasping a tile, sense the contents of any cell (regardless of distance or line-of-sight obstructions), and request the current world time.

Commands that control NTW are logically divided into three categories: (i) commands used to create a problem instance, tune simulator parameters, adjust the behavior of exogenous events, and introduce uncertainties into the outcomes of actions; (ii) commands that the agent controller uses to interact with NTW; and (iii) commands used to modify the display interface.

In NTW, the exogenous events (i.e., events that the agent cannot control) are implemented as gusts of wind that blow from the borders of the grid toward the interior. The detailed behavior of these gusts is difficult for the agent to predict. Another source of difficulty in prediction is uncertainty in the outcomes of actions, which is realized within NTW by specifying a probabilistic model of alternative outcomes when a particular NTW problem instance is constructed. The result of this is that the agent controller must sense the world to determine whether an action has achieved the intended effects. In addition to exogenous effects and uncertain outcomes of actions, NTW supports the study of "metric time." This refers to temporal properties of the domain or task. In NTW, the user can study this by fine-tuning the metric temporal properties of the simulator program; for example, the velocity and period of a wind, and the velocity of an agent.

NTW is written in Allegro Common Lisp for Sun-3- and Sun-4-series computers running SunOS. This program requires version 3.1.13 or version 4.0 of Allegro Common Lisp as well as the Common Lisp loop macro. The standard distribution medium for NTW is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge in UNIX tar format. An electronic copy of the documentation is included on the program medium. NTW was developed in 1991.

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This program was written by Andrew Philips, John Bresina, and Mark Drummond of Sterling Software for **Ames Research Center**. *For further information,* ***write in 47*** *on the TSP Request Card.*
ARC-13212

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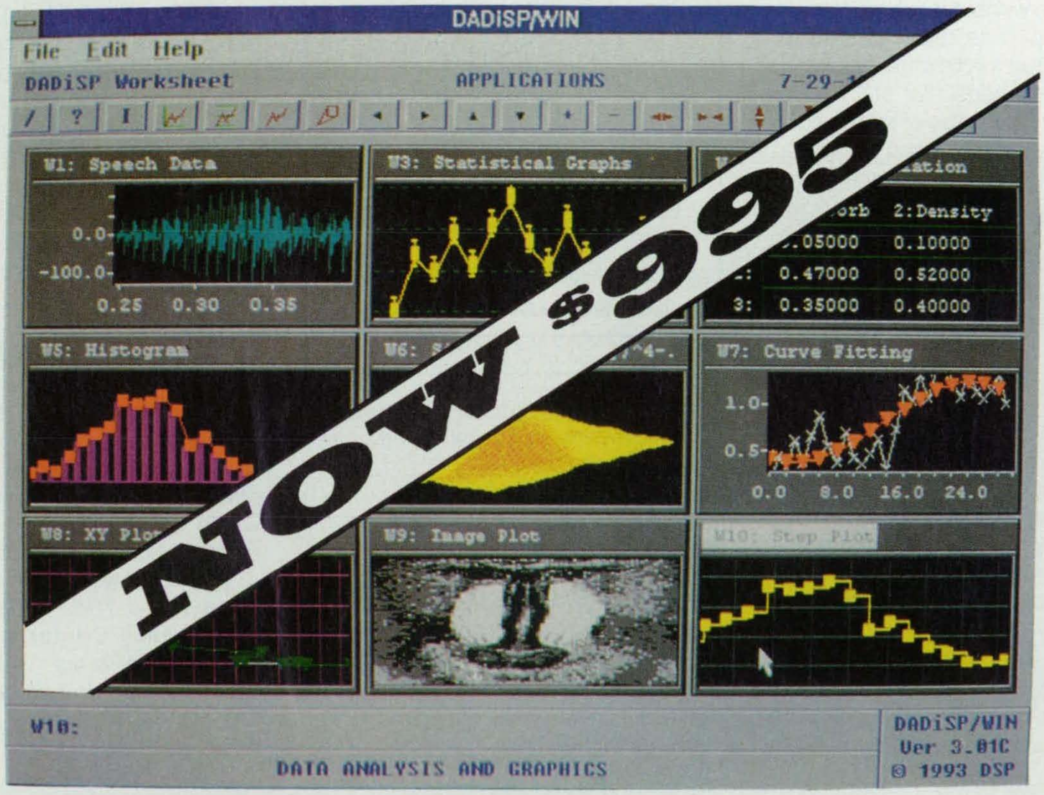

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Mechanics

Vortex-Shedding Meters for Liquid and Liquid/Gas Flows

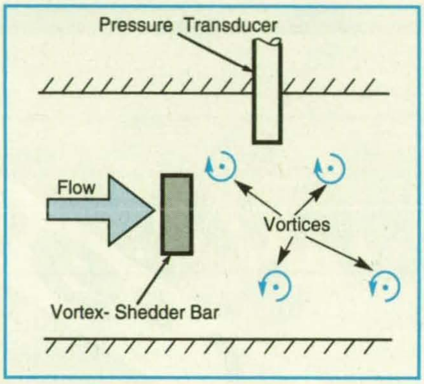
These meters contain no moving parts.

John F. Kennedy Space Center, Florida

Flowmeters without moving parts are being developed as replacements for conventional turbine flowmeters, which contain moving parts that are subject to wear. The disassembly of turbine flowmeters for maintenance and repair can interrupt critical processes and/or release toxic or corrosive fluids, the flows of which are to be measured. In contrast, no maintenance is required for flowmeters without moving parts, and so these meters can be installed permanently.

The flowmeters without moving parts are based on vortex shedding — the formation of vortices by liquids flowing over bluff bodies. Vortices are shed alternately at opposite sides of the trailing face of such a body and move away at a speed slightly less than that of the flow being measured. The frequency of formation of vortices is proportional to the rate of flow.

In a vortex-shedding flowmeter, a piezoelectric or other suitable transducer probe senses the changes of pressure caused by the passage of the vortices (see figure). Electronic circuitry processes the pressure-change signals to extract the vortex-passage frequency that represents the rate of flow.



The **Pressure Transducer** senses passing vortices generated at the trailing edges of a shedder bar.

Vortex-shedding flowmeters with outside diameters up to 2 in. (5.08 cm) have been tested with water and trichlorotrifluoroethane flowing at rates up to 200 gal/min (757 L/min). Vortex-shedder bars that have cylindrical, wedge, and rectangular shapes have been tested in experiments. All have been found to shed vortices at frequencies that increase linearly with rates of flow. In this respect, the frequency-vs.-flow-rate characteristics of the vortex-shedding flowmeters closely resemble those of turbine flowmeters. The rectangular and wedge shedder bars have been found to yield stable vortices, thereby facilitating the counting of fluctuations of pressure to determine the frequencies of vortex shedding. The rectangular vortex shedder will probably be the easiest to manufacture. Because of its symmetry, the rectangular vortex shedder would also be suitable for measurements of bidirectional flow.

This work was done by Robert H. Howard and William Larson of **Kennedy Space Center** *and Ngo Dinh Thinh of California State University, Sacramento. For further information,* ***write in 103*** *on the TSP Request Card.* *KSC-11582*

Gyroless Yaw-Estimating System

Yaw angle is estimated from rate equations and sensor signals.

Goddard Space Flight Center, Greenbelt, Maryland

An algorithm estimates the yaw of a spacecraft from equations of motion and readings of nongyroscopic sensors. The algorithm is intended to be used in monitoring and controlling yaw when a yaw gyroscope fails. A modified version of this algorithm might be similarly useful in monitoring and controlling the yaw of a terrestrial scientific instrument or of an aircraft.

Figure 1 shows the applicable coordinate system. The dynamical state of the spacecraft or other object at small yaw and roll angles can be represented by a mathematical model that consists of four state variables and the corresponding ordinary differential equations, as follows:

$$\dot{\Psi} = \omega_x + \omega_o \phi$$

$$\dot{\phi} = \omega_y - \omega_o \Psi$$

$$\dot{\omega}_x = I_x^{-1}[T_x + (I_z - I_y)\,\omega_o \omega_y]$$

$$\dot{\omega}_y = I_y^{-1}[T_x + (I_z - I_x)\,\omega_o \omega_x]$$

where Ψ is the yaw angle (the quantity that is sought); ω_x is the rate of yaw; ϕ is the roll angle; ω_y is the rate of roll; ω_o is the angular rate of orbital motion; I_x, I_y, and I_z are the roll, pitch, and yaw inertias, respectively; and T_x and T_y are the totals of control plus disturbance torques applied about the yaw (x) and roll (y) axes, respectively.

Because these equations are cross-coupled, one can use them to reconstruct the yaw angle and the rate of yaw, given the roll angle and other quantities. This reconstruction is performed by the algorithm, which is of the observer/esti-

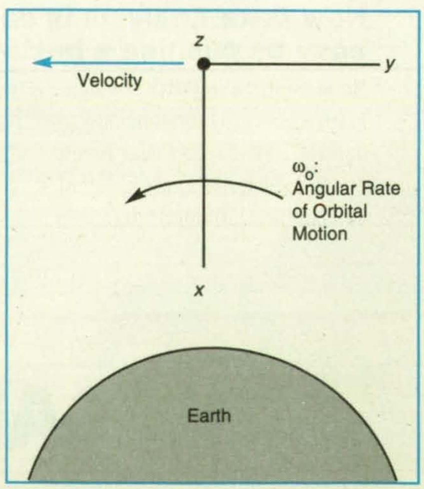


Figure 1. This **Moving Coordinate System** defines some of the quantities in the equations of motion.

mator type (see Figure 2). The algorithm estimates the yaw iteratively by first computing the difference between the actual roll as measured by an Earth sensor and the previously estimated roll, then using this difference (which is called the "estimator error") to force the state variables of the mathematical model to converge to the actual state variables of the spacecraft. In this computation, the estimator error is scaled by estimator gains (denoted in Figure 2 as K_{e1} through K_{e4}) and added to each of the four differential equations in the Laplace-transform domain.

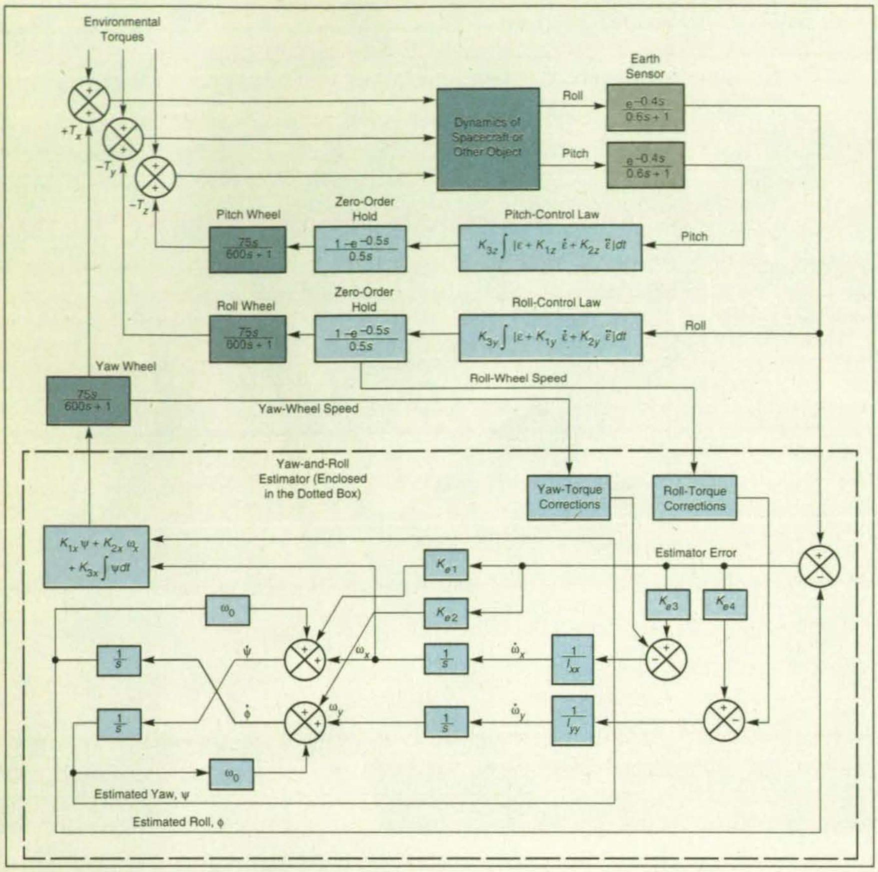


Figure 2. The **Gyroless Yaw Estimator** is implemented as an observer/estimator algorithm.

The estimator gains are chosen to make the state variables of the mathematical model converge to the actual state variables in critically damped fashion in less than one orbital period. Once convergence has occurred, the yaw angle and rate of yaw as estimated by the algorithm can be used for monitoring and control in the event of failure of the yaw gyroscope. The algorithm has been tested by computer simulation and found to yield stable convergence in the presence of unmodeled disturbances. The worst-case steady-state error in the estimated yaw angle and rate of yaw in the original spacecraft application were found to be ±5.0° and 0.002°/s. Convergence was found to be possible from initial yaw errors up to ±30°. The simulation showed that at initial yaw errors of 40°, the estimate diverges.

This work was done by John B. Stetson, Jr., of General Electric Co. for **Goddard Space Flight Center**. *For further information,* ***write in 7*** *on the TSP Request Card.* GSC-13459

Computing Flow Transition on Parallel Processors

A parallel algorithm is developed on a multiple-microprocessor computer.

Langley Research Center, Hampton, Virginia

Although viscous-flow transition has been studied experimentally, numerically, and theoretically for the past 30 years, some of the fundamental mechanisms remain elusive. Most of the work has focused on the analysis of incompressible flow because of its relative simplicity from both the numerical and theoretical points of view. The expected laminar, partially turbulent, or completely turbulent flow over a wing surface greatly influences the aerodynamical properties and stress load on the wing and thereby affects the weight and other aspects of design, ultimately affecting cost of production.

Therefore, a program was initiated at NASA Langley Research Center to develop computer codes capable of directly simulating and mathematically modeling the transition process at mach numbers ranging from the subsonic to the hypersonic. However, such computer codes require huge amounts of processing time on the largest supercomputers to solve even the simplest problems. Parallel computers potentially offer a reduction of processing time; the processing time should be inversely proportional to the number of available processors.

In one implementation of this concept, the three-dimensional, time-dependent Navier–Stokes equations of compressible flow were solved on a 20-processor Flex/32® computer at NASA Langley Research Center. A three-dimensional spectral algorithm was developed on the Flex/32 shared memory multiprocessor. This algorithm was originally designed for, and run on, the Cray-2® computer as a conventional uniprocessor code to study the transition of compressible flow over a flat plate. In view of the anticipated availability of multiprocessing on the Cray-2 computer and the scope for parallelism in the algorithm, it was decided to modify this code for parallel operation on the Flex/32 computer. The Navier–Stokes compressible-flow program was ported from the Cray-2 computer at Ames Research Center to the Flex/32 computer at Langley Research Center.

This work has two significant aspects. First, the spectral algorithm, as applied to the three-dimensional Navier–Stokes equations of compressible flow, is new and original. It is expected that the implementation of this algorithm on super multiprocessors like the Cray-2 computer will enable a practical number of parametric studies in a reasonable time. Second, it has been demonstrated that small multiprocessors based on inexpensive microcomputers can indeed be used as "workbenches" for the development of parallel algorithms intended to be used on super multiprocessor computers. Further work is planned to examine parallel algorithms for use on the hypercube-connected parallel processors.

This work was done by S. Bokhari of the National Research Council and G. Erlebacher of **Langley Research Center**, *and M. Y. Hussaini of the Institute for Computer Applications in Science and Engineering. For further information,* ***write in 81*** *on the TSP Request Card.* LAR-14303

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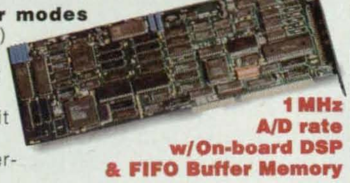

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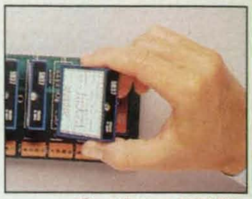

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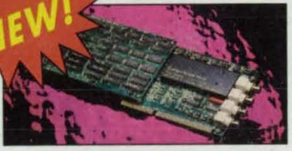

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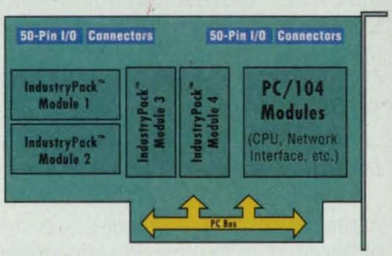

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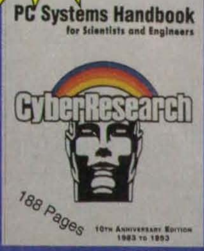

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General-Purpose Time-Accurate Adaptive-Grid Method

Grids for computations of compressible flows are adapted to evolving solutions.

Langley Research Center, Hampton, Virginia

An adaptive-grid method provides for the generation of time-accurate grids that can be used to solve a wide variety of problems numerically. The principal intended use is in the computation of compressible flows.

This particular adaptive-grid method is part of a solution method that includes (1) an algebraic grid-movement scheme, (2) an algorithm that solves, by use of an explicit numerical-integration scheme, the Euler equations of unsteady flow, and (3) a temporal coupling routine that utilizes a grid-prediction/correction method to link the dynamic grid with the Euler-equation-solving algorithm. This method improves the ability to adapt the grid to multiple features of the solution and involves the use of a coarse grid in the prediction stage of the temporal coupling that reduces the central-processing-unit cost of obtaining the new grid.

The grid-movement scheme employs a "monitor surface" formed from the solution data to identify regions in which higher grid resolution is needed. The grid points are repositioned on a curve-by-curve basis by requiring that a weighting function be equally distributed along each curve. To ensure that both the gradients and the transition regions of the solution are resolved, the weighting function includes terms that represent the gradients and the normal curvature of the monitor surface along the curve. The weighting function also includes a grid control that does not allow the grid cells to become too small.

One requirement for the accurate adaptation of the grid to multiple features of the solution that merge when the solution is computed is that the monitor surface be defined as a vector function rather than as a scalar function. If the monitor surface is a scalar function of the multiple features of the solution and if the solution features happen to merge in a particular case, then the solution gradients cancel each other and thereby destroy the grid in the region of merger. With the monitor surface defined as a vector function, the gradients of the features being tracked cannot cancel, and thus good grid resolution is maintained in the region of merger. The process for adaption of a grid to a vector monitor surface is essentially the same as for a scalar monitor surface.

In the grid-prediction/correction method, the time integration of the solution is treated as a series of initial-value problems over short intervals, in each of which the solution is first advanced to create a new grid and then recomputed on the new grid. Because the new grid is based on solution data forward in time, there is no time lag between the grid and the solution.

A series of numerical tests of the method were performed by applying it to an unsteady-shock-tube-flow problem. Solutions were computed on uniform stationary grids (100×2, 500×2 cells) and adaptive grids (100×2 cells). The solutions obtained by use of adaptive grids were generally in closer agreement with the exact solution than was the solution obtained in the 100-cell stationary grid, whereas the solution obtained on the 500-cell stationary grid was comparable to those obtained by use of the adaptive grids. Both stationary-grid solutions maintained the total mass, but the correct speed of propagation of the shock was obtained only on the finer stationary grid. The adaptive-grid solutions exhibited small loses of mass and a 1-percent error in the speed of propagation of the shock.

The method was also tested by applying it to a shock/vortex-interaction problem. The flow field was assumed to lie within a solid walled channel and to consist of an initially planar shock wave marching toward, and eventually over, a simple solid-core vortex. For boundary conditions, tangential flow was assumed along the walls, and simple extrapolation was performed at the inlet and outlet. The adaptive grid was generated with a vector monitor surface formed from the density field (to track the shock) and the circulation about each grid point (to track the vortex). The adaptive grid correctly captured the time-dependent location and shape of the shock wave and the vortex.

Fewer mesh points are needed for computations of a given accuracy on grids fitted to the irregularities of the solution by use of this method than are needed on uniform grids. Where computations of complicated flows require hundreds or thousands of mesh points, such as in the design of airfoils and turbines or in other compressible-flow applications, adaptive methods that can significantly reduce these computations are attractive.

This work was done by Michael J. Bockelie of the National Research Council, Robert E. Smith of **Langley Research Center**, *and Peter R. Eiseman of Columbia University. For further information,* ***write in 23*** *on the TSP Request Card.*

LAR-14634

Fixture for Hot Stress Tests of Thin Specimens

The fixture both applies heat and prevents buckling.

Langley Research Center, Hampton, Virginia

The figure shows aspects of a fixture designed to hold and heat a thin, rectangular-cross-section specimen of composite material during a hot lengthwise-stress test. The fixture is suitable for testing the same specimen in either tension or compression. The fixture clamps lightly onto the specimen, providing both heat via thermal conduction and the lateral support that is needed to prevent buckling during a compression test.

The fixture is made of 2024 aluminum machined into two matching halves. Each half of the fixture contains two resistance heater rods, which fit snugly into a hole bored lengthwise. Two-zone control of the applied heat is achieved by use of a separate control unit for each half of the fixture, with a thermocouple probe in each half used for feedback. The thermocouple probes are located at the midlength of the fixture and embedded full depth into the fixture via a tolerance-fit hole. Heat is transferred from the fixture to the specimen through direct contact along the entire length of the fixture and across the entire width of the specimen.

The loss of heat is suppressed by enveloping both the specimen and the fixture in a clamshell-shaped fiberglass insulator lined with reflective foil. Thermocouple-probe measurements along the length of this insulated fixture indicated that the variation of temperature along the length of the heated section is less than 5 percent. Stable control of the applied heat is maintained to within 1°C, as indicated by measurements

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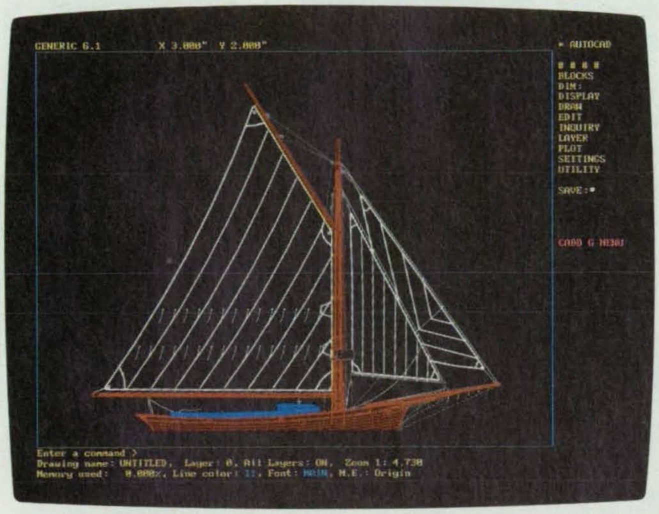

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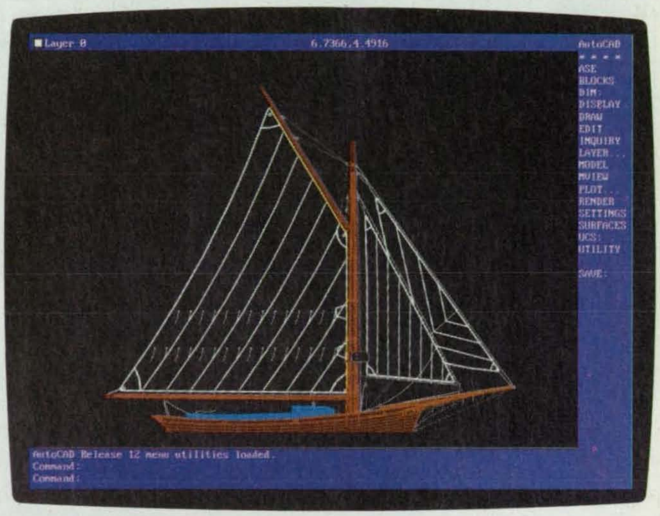

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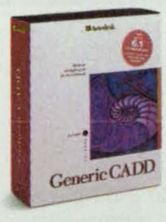

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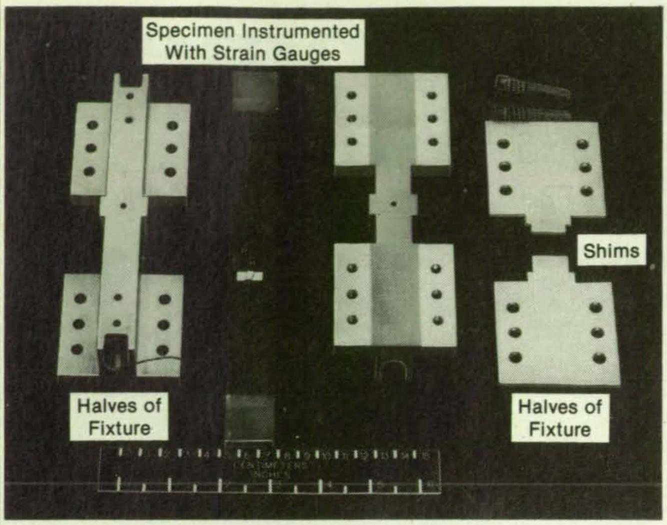
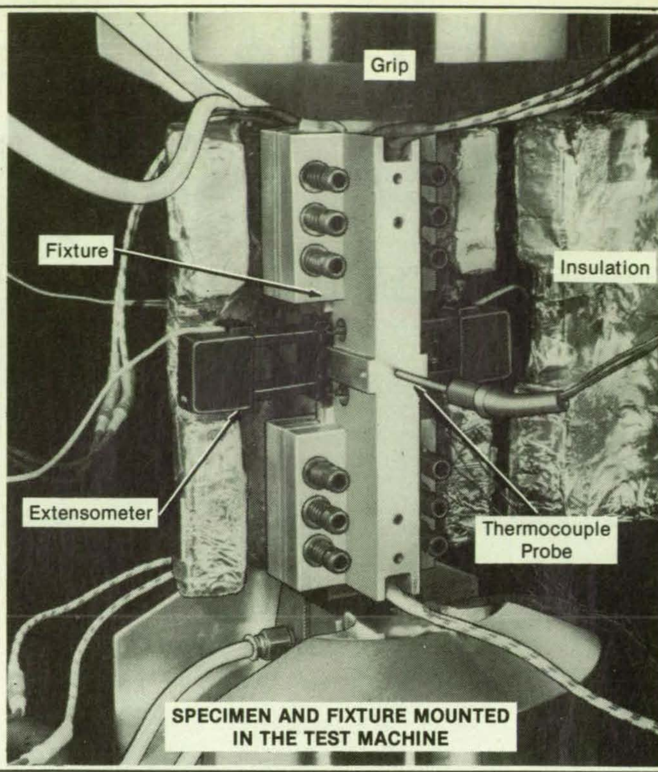


SPECIMEN AND FIXTURE



SPECIMEN AND FIXTURE MOUNTED IN THE TEST MACHINE

The **Test Fixture** both heats the specimen to a controlled temperature and provides gentle lateral support against buckling during a compression test.

taken via the feedback probes.

The constraint against buckling during a compression test is achieved by connecting the two halves of the fixture with spring-tensioned screws at a number of positions along the length. Because of the continuity of this support along the length of the specimen, only a small lateral force is needed to suppress buckling. Because this force is small, it exerts no more than a minimal effect on the strain response of the specimen in either a tension or a compression test. Polytetrafluoroethylene tape reduces friction between the specimen and the fixture.

The strain response of the specimen can be measured by use of strain gauges and/or extensometers. For strain-gauge measurements, partial-length shims can be inserted between the two halves of the fixture. The length of the shims can be adjusted to provide a small gap centered over each gauge. Notched sections on the edges of the fixture expose edge sections of the specimen at the midlength. Opposing extensometers can be attached to the specimen at these exposed edge sections.

This work was done by Thomas S. Gates of **Langley Research Center**. *For further information,* ***write in 50*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquires concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 22]. Refer to LAR-14775.

Two-Stage Reduction of Dynamical Models

It is no longer necessary to solve eigenvalue problems of high order.

NASA's Jet Propulsion Laboratory, Pasadena, California

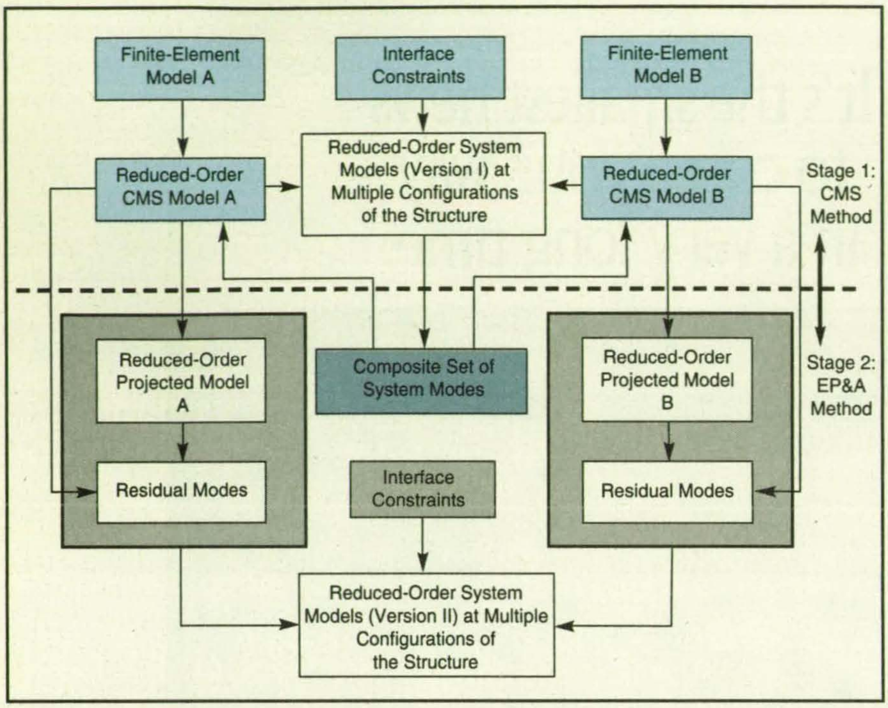
The component-mode projection-and-assembly model-reduction (COMPARE) method provides an approximation of the dynamics of vibrations of complicated, multiple flexible bodies by use of mathematical models of reduced order. The COMPARE method incorporates the component-mode synthesis (CMS) method and the enhanced projection-and-assembly (EP&A) method, providing for a somewhat simplified two-stage process in which the order of the applicable mathematical models is reduced. The reduced-order models could be used, for example, to design algorithms of control systems to suppress vibrations or otherwise control the structure.

The EP&A method was described in "Enhanced Method of Reduction of Dynamical Models" (NPO-18402), *NASA Tech Briefs*, Vol. 16, No. 7 (July 1992), page 70. To recapitulate: In the EP&A method, vibrational and rigid-body modes that contribute significantly to the dynamics of the overall structure are first selected, then projected (in an abstract mathematical sense) onto the components of the structure. The resultant reduced-order mathematical models of the components are assembled, along with static correction modes in the form of Ritz vectors, to obtain a reduced-order model of the system that captures the selected system modes.

To compute the modes used in the EP&A method, eigenvalue problems of the full-order models of the entire structure (system models) at all configurations of interest must be solved repetitively. Because the solution of such large eigenvalue problems can be costly, this is a disadvantage of the EP&A method. The COMPARE method was developed to overcome this disadvantage.

The steps of the COMPARE method are grouped together into two stages (see figure). The first stage involves the CMS method, which is an approximation method, based on the Rayleigh–Ritz method, that has been used to analyze linear, high-order structural-dynamics

problems. First, sets of modes of the MacNeal–Rubin or Craig–Bampton type are used to reduce the order of the mathematical model of each component in the Rayleigh–Ritz sense. The resulting sets of component modes are then assembled, using interface compatibility conditions, to generate reduced-order system models of the structure in its various configurations. The order of these reduced-order system models is much lower than that of the full system model.



In the **COMPARE** method, reduced-order mathematical models of the dynamics of a complicated, flexible structure are generated in a two-stage process.

In the second stage, the EP&A method is employed to reduce further the order of the system models generated in the first stage. First, a composite set of modes that contains the important system modes at all configurations of the structure is selected from the reduced-order system models. The composite set of modes is projected onto the component models that were generated by the CMS method in the first stage. The projected component models are then augmented with static correction modes (residual modes) before being reassembled to generate the final reduced-order system model. In this way, COMPARE retains the advantages, without the disadvantages, of both the CMS and EP&A methods.

This work was done by Allan Y. Lee and Walter S. Tsuha of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 1*** *on the TSP Request Card.*
NPO-18723

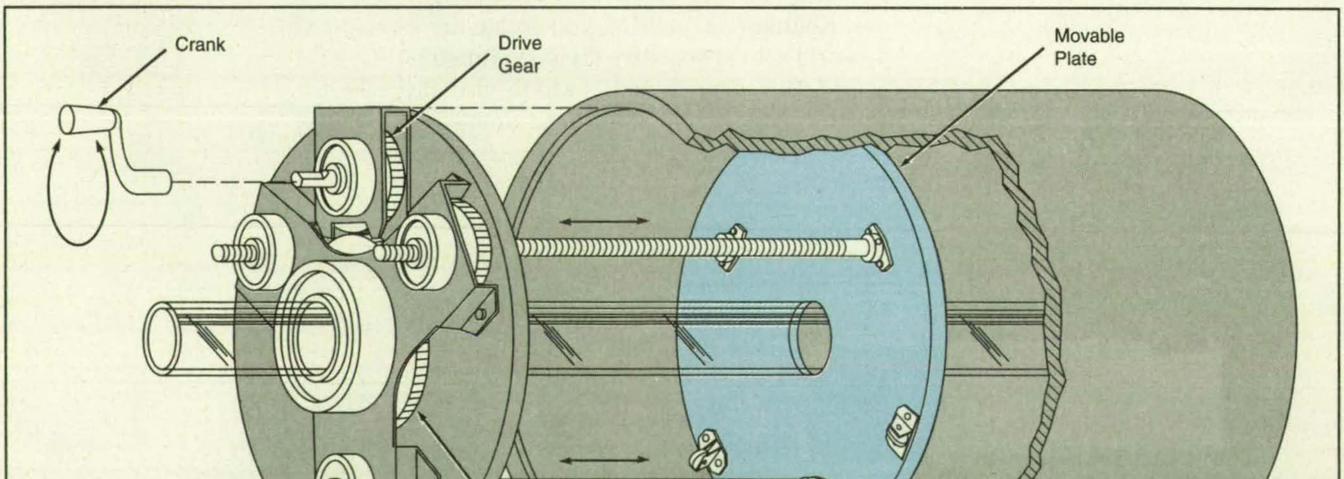
Three-Point Gear/Lead Screw Positioning

The mechanism helps keep the driven plate parallel to a stationary plate.

Lewis Research Center, Cleveland, Ohio

A triple-ganged-lead-screw positioning mechanism drives a movable plate toward or away from a fixed plate and keeps the plates parallel to each other. The mechanism was designed for use in tuning a microwave resonant cavity, wherein the parallel plates are the end walls, the distance between which is the critical dimension to be adjusted. Other potential applications for this or similar mechanisms include adjustable bed plates and cantilever tail stocks in machine tools, adjustable platforms for optical equipment, and lifting platforms.

In the original tunable-microwave-cavi-



The **Triple-Ganged-Lead-Screw Mechanism**, shown here greatly simplified, positions the movable plate along the track while keeping the movable plate parallel to the fixed plate.

ty application, the new mechanism replaces a variety of prior mechanisms, some of which included single-point drives that were subject to backlash (with consequent slight tilting and uncertainty in the distance between the plates). Other prior mechanisms relied on spring loading, differential multiple-point drives, and other devices to reduce backlash. In providing three-point drive along a track between the movable and fixed plates, the new mechanism ensures the distance between, and parallelism of, the two plates via the fundamental geometric principle that three points determine a plane.

The moving parts of the mechanism are mounted on a fixed control bracket that, in turn, is mounted on the same rigid frame that holds the fixed plate and the track along which the movable plate travels (see figure). A large central gear turns on precise ball bearings and drives three identical pinion gears at the corners of an equilateral triangle. The central gear is driven by a hand-cranked or motor-driven drive gear similar to one of the pinion gears.

Each pinion gear is mounted on a hollow shaft that turns on precise ball bearings, and the hollow shaft contains a precise internal thread that mates with one of the lead screws. One end of each lead screw is attached to the movable plate. The meshing of the pinions and the central gear is set so that the three lead screws are aligned with each other and the movable plate is parallel with the fixed plate.

This work was done by Frank S. Calco of **Lewis Research Center**. *For further information,* ***write in 9*** *on the TSP Request Card.*

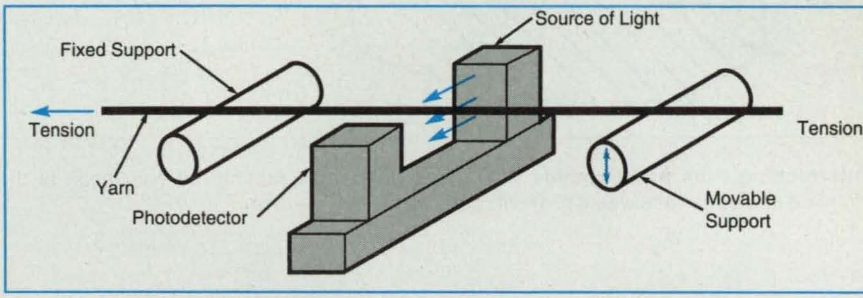
This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Lewis Research Center [see page 22]. Refer to LEW-15216.

Continuous Measurement of Mass Density of Yarn

Mass density is determined by optical monitoring of vibrations.

Langley Research Center, Hampton, Virginia

A prototype instrument provides measurement data from which one can compute the mass density of a strand of yarn. A production version of the instrument could be used for continuous real-time monitoring of such yarn-manufacturing processes as coating or impregnation. Unlike the conventional method of measuring the mass density of yarn — cutting off pieces of yarn and weighing them — the use of this instrument would not interrupt manufacturing.



A **Beam of Light Illuminates the Vibrating Yarn** while a photodetector in the shadow of the yarn detects the vibrations.

The instrument includes fixtures that place a known length (L) of yarn under a known tension (T) across a fixed and a movable support. Transverse vibrations are induced in the yarn by moving the movable support up and down (see figure). The movable support can be made to excite the yarn in either of two ways: it can apply a single pulse to generate free vibration or it can jiggle the yarn continuously to adjust the frequency of excitation gradually until resonance is found.

A source of light illuminates a photodetector at the midlength of the yarn, and the photodetector senses the repeated shadowing caused by the vibration of the yarn through the light, thereby measuring the vibrations. The electrical pulses generated by the photodetector are amplified and subjected to fast-Fourier-transform analysis to determine the fundamental frequency of vibration (f). In principle, one can then compute the mass per unit length (m) by use of the well-known theory of a vibrating string, which predicts that

$$m = \frac{T}{4(Lf)^2}$$

In practice, the stiffness of the yarn (caused principally by the coating or impregnating material) may alter this functional dependence slightly, necessitating preproduction calibration measurements.

This vibrational method offers advantages over other ways of measuring the mass density of yarn continuously. For example, in the capacitance method, in which one measures the mass-related capacitance of the yarn, one must maintain a precise gap between a sensor and the yarn; this is difficult when the thickness of the yarn varies. Moreover, capacitance measurements are subject to electromagnetic interference. Unlike nuclear-radiation gauges, the vibrational apparatus does not include potentially hazardous radioactive isotopes. The vibrational apparatus is also cheaper.

This work was done by Jeffrey A. Hinkley of **Langley Research Center**, *Joseph M. Marchello of Old Dominion University, and John D. Johnston of the University of Rochester. For further information,* ***write in 93*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 22]. Refer to LAR-14879.

Radial Splines Would Prevent Rotation of Bearing Race

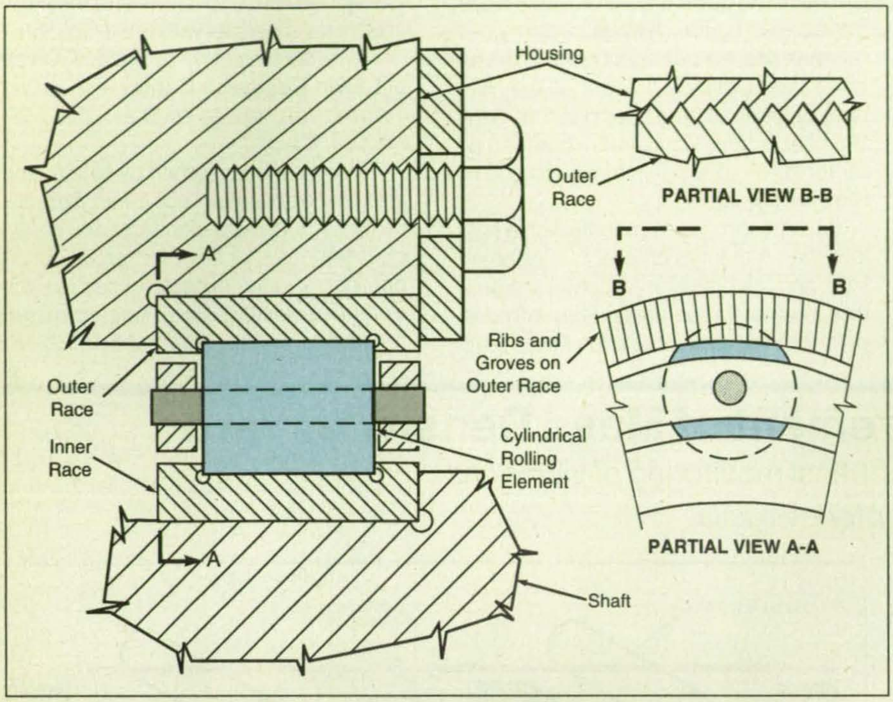
The splines could bear large torque loads and would impose minimal distortion on the raceway.

Lewis Research Center, Cleveland, Ohio

Interlocking fine-pitch ribs and grooves would be formed on the otherwise flat mating end faces of a housing and the outer race of a rolling-element bearing to be mounted in the housing, according to a proposal. When the bearing was mounted in the housing and clamped axially to enforce engagement of the radial splines, the race would be restrained against rotation in the housing.

Rotation of the outer race must be prevented because it causes wear. It is especially difficult to prevent rotation of the outer race of a roller bearing in which the internal clearances are made nega-

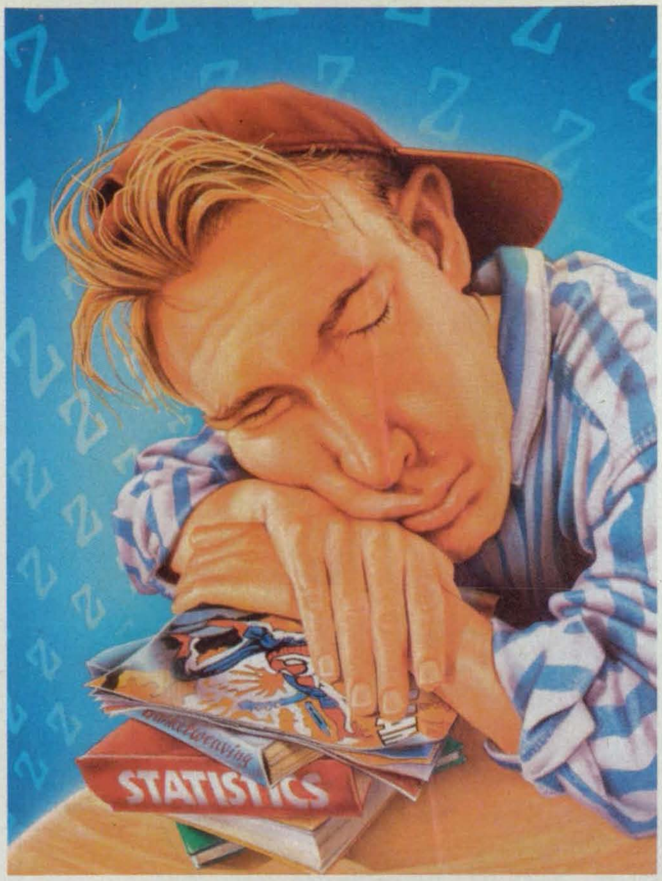
tive to ensure stability of the rollers. One prior technique for preventing such rotation is axial clamping of the race to the housing by use of a spanner nut. Another technique involves an outer race equipped with a flange that is bolted to the housing. In some applications, there is not enough room for a bolted flange. In general, it has been difficult to prevent rotation by use of other components and features that are simultaneously (1) large enough to exert sufficient restraining torque, (2) small enough to satisfy competing design limits on size, and (3) separated from the raceway by material of sufficient thickness to suppress effectively any distortion of the raceway (and consequent loss of durability) caused by the loads that these features exert.

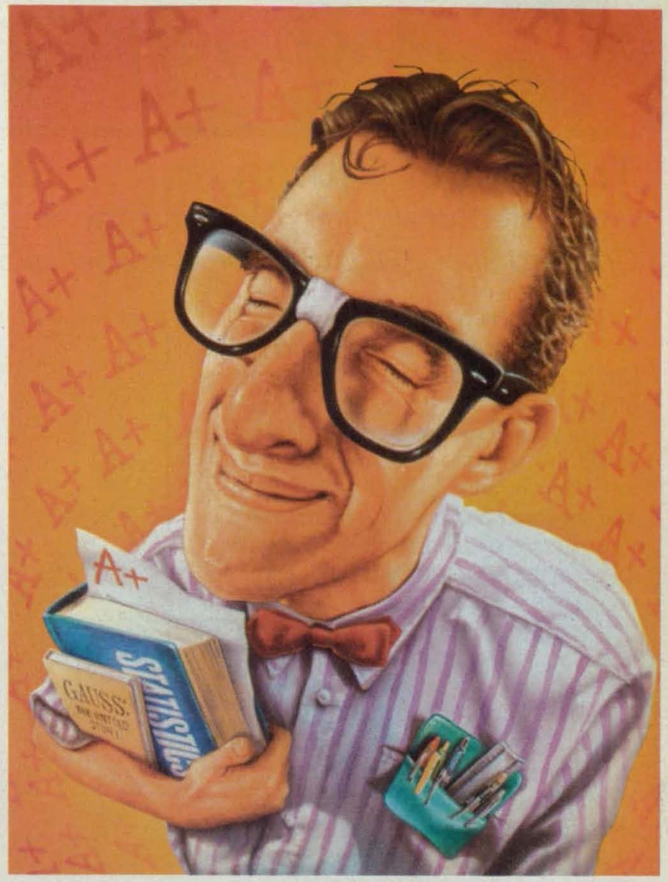


Interlocking Ribs and Grooves (radial splines) on the mating flat end faces of the housing and outer race would prevent rotation of the outer race.

The proposed radial splines would overcome these difficulties in three ways: (1) They would be compact. (2) Radial splines are generally recognized to be capable of bearing torque loads that are large in comparison with those born by other parts of comparable size. (3) Placing the splined surface on the flat end face of the race removes it as far as possible from the path of the rolling elements, minimizing distortion of the raceway.

This work was done by Ronald M. Kaplan and Jaisukhlal V. Chokshi of United Technologies Corp. for **Lewis Research Center**. *No further documentation is available.*
LEW-15149





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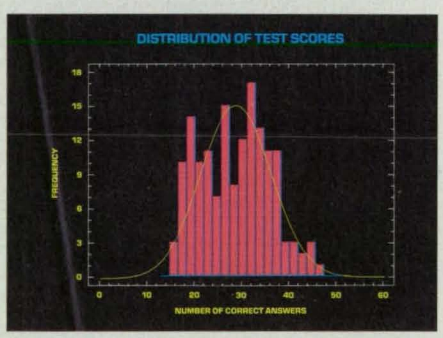

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For More Information Write In No. 399

Trip Roller Clutch

This bidirectional roller-locking mechanism offers advantages of efficiency and controllability.

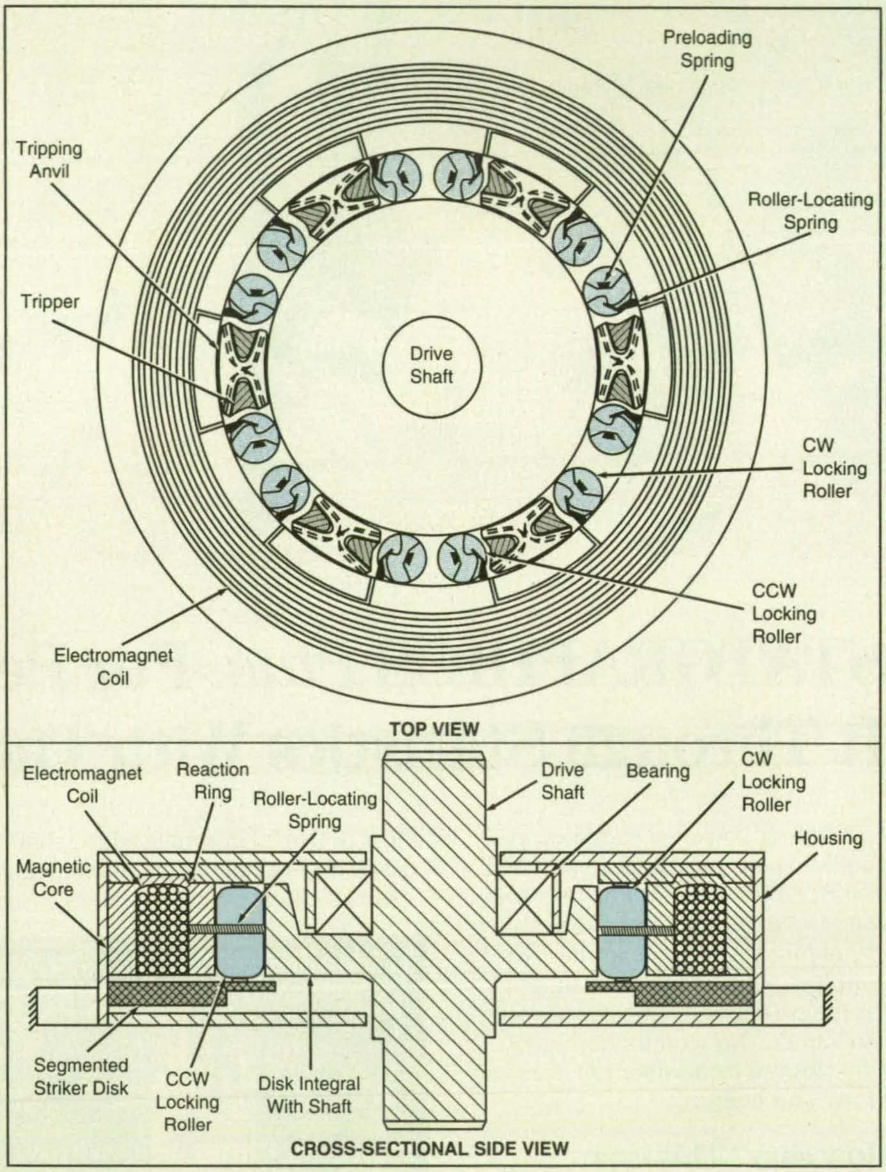
Goddard Space Flight Center, Greenbelt, Maryland

The figure is a simplified cross-sectional view of an electromagnetically releasable roller-locking mechanism that functions as a brake or clutch in clockwise or counterclockwise rotation. In essence, the mechanism contains two back-to-back overrunning clutches like those that are commonly used in industry to roll freely in one direction and lock against rolling in the opposite direction. In addition to bidirectionality, the novel design of this mechanism offers advantages of efficiency and controllability over older clutches and brakes.

As in other roller-locking mechanisms, lock is achieved in this mechanism by jamming rollers between a precise surface on one rotating or stationary subassembly (in this case, the inner surface of a reaction ring in a housing) and a precise surface on another rotating or stationary subassembly (in this case, the outer surface of a disk integral with a drive shaft). There are two sets of rollers: CW and CCW locking rollers, which feature cam surfaces that jam against the disk and reaction ring in the event of clockwise and counterclockwise rotation, respectively. The mechanism is called a "trip roller clutch" because of the manner in which the rollers are unjammed or tripped to allow rotation, as explained below.

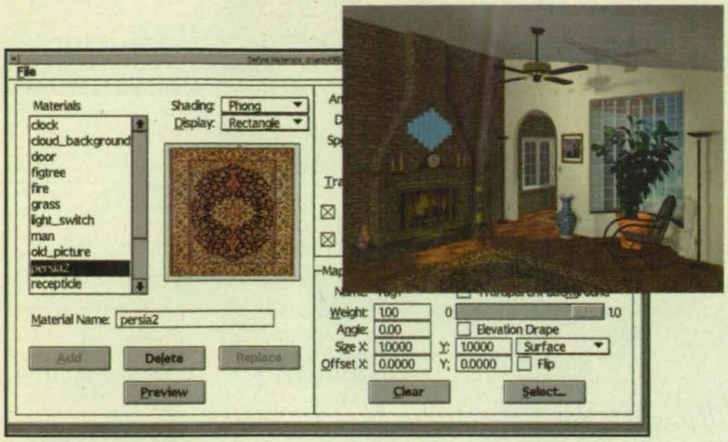
The rollers are arranged in pairs around the disk and the reaction ring. Each pair contains one CW and one CCW locking roller. A tripping anvil fixed to the reaction ring is located between the rollers in each pair. Each roller is spring-loaded to translate toward a prescribed small distance from the tripping anvil and to rotate toward the incipient-jamming position. In the absence of any tripping or releasing action, the clutch remains in lock; that is, any attempt at clockwise or counterclockwise rotation of the drive shaft results in jamming of the CW or CCW rollers, respectively.

Release is effected by energizing the electromagnet coil in the housing. The resulting magnetic force pulls a segmented striker disk upward against spring bias. Attached to each segment of the striker disk is a tripper, which slides toward a CW or CCW roller on precisely angled surfaces in the tripping anvil. Each tripper then pushes against its associated CW or CCW locking roller with a small blocking force. But, in blocking the locking roller, the locking cam angles are effectively increased and slipping (followed by release) occurs. Thus, the clutch is "tripped" out of lock into release.



The **Trip Roller Clutch** contains back-to-back roller-locking, overrunning clutches that can be released (tripped) with small magnetic forces.

Very little force is needed for this releasing action, even though the forces in lock can be very large. Because the gap between the striker plate and the magnetic core is zero or very small during release, very little magnetic force is needed to maintain release; thus, the electromagnet coil and the power it consumes can be made smaller than in comparable prior mechanisms, with a corresponding gain in power efficiency and decrease in size and in weight. To lock the clutch, one simply turns off the electromagnet, allowing the springs to retract the trippers and restore the rollers to



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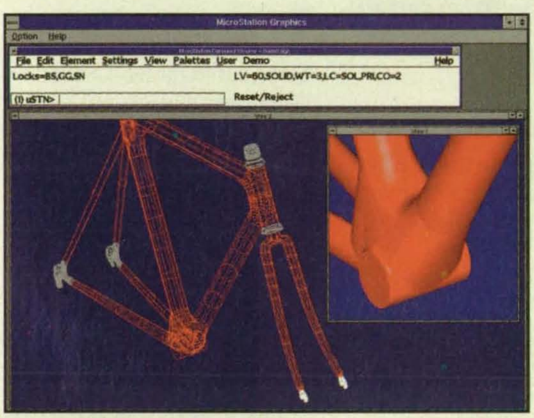

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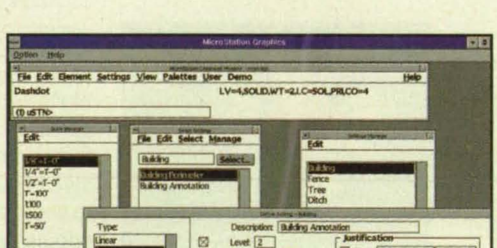

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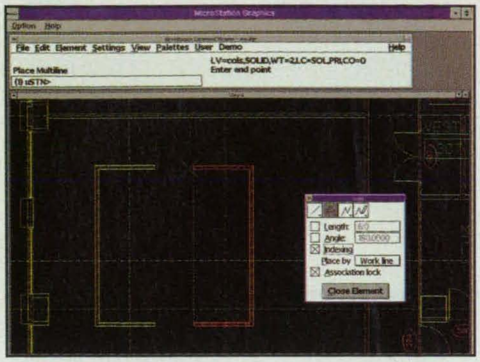

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the incipient-jamming position.

The excellent frequency response and high mechanical efficiency inherent in roller locking enable the trip roller clutch to be lockable and releasable precisely at a desired torque under sensory interactive computer control. For the same reasons, the trip roller clutch can be opened and closed repeatedly in a pulsating manner to maintain precise torque(s) or to effect release under impending slip, as in an automative antilock braking system. It operates more predictably than do other friction-based clutches in that its performance is not disturbed when lubricant is dropped on it; indeed, it is designed to operate with lubricant. Also, unlike other friction-based devices, the trip roller clutch remains cool during operation.

This work was done by John M. Vranish of **Goddard Space Flight Center** *and supported by Honeybee Robotics, NY. For further information,* ***write in 100*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center [see page 22]. Refer to GSC-13502.

Dehumidifying Heat Pipe

A unit fits in a conventional air conditioner.

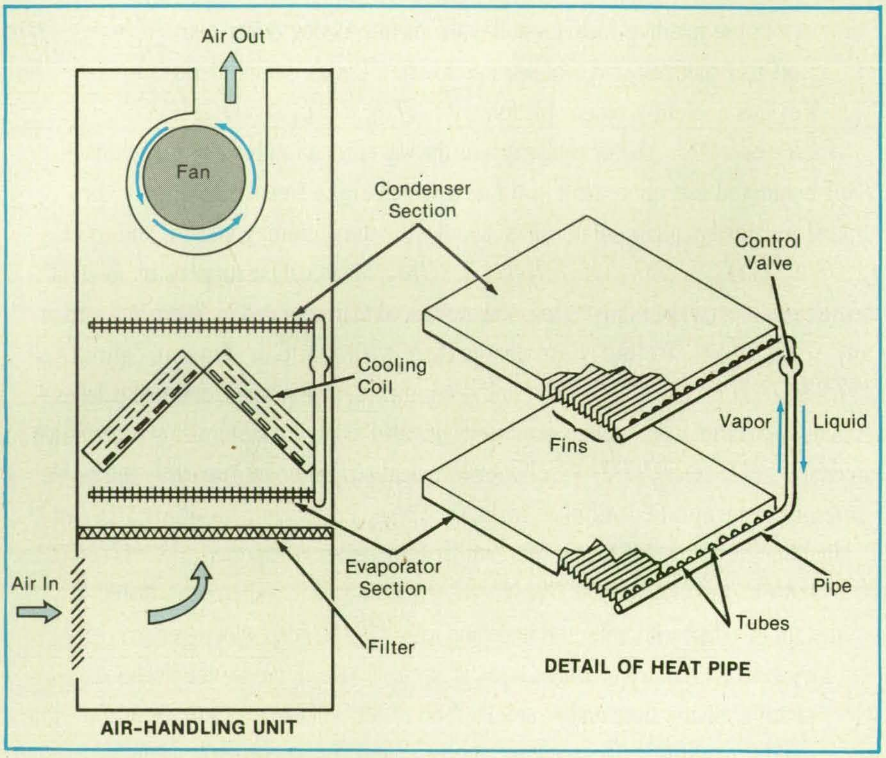
John F. Kennedy Space Center, Florida

A U-shaped heat pipe partly dehumidifies air leaving an air conditioner. The heat pipe fits readily in the air-handling unit of the conditioner.

The evaporator and condenser sections of the heat pipe consist of finned tubes in a comb pattern (see figure). Each tube is sealed at one end and joined to a manifold at the other. The sections are connected by a single pipe that carries vapor to the condenser manifold and liquid to the evaporator manifold.

Warm air returning to the cooling coil of the air conditioner flows over the evaporator section of the heat pipe, heating the working fluid so that it vaporizes and flows to the condenser section. Because the evaporator section is almost as cool as the outgoing air is, some of the moisture in the incoming air condenses on it and drips into a receptacle. Some of the moisture in the incoming air also condenses on the cooling coil. The colder, drier air that has passed through the cooling coil is warmed slightly by the condensation of vapor in the condenser section of the heat pipe. The condensed vapor (now liquid) is thus cooled and flows back down to cool and feed the evaporator section of the heat pipe.

A simple on/off or proportional valve can be used to control the flow of working fluid. The valve can be actuated by a temperature/humidity sensor.



Sections of the Dehumidifier Fit above and below the cooling coil of an air conditioner. Finned tubes are about 19 in. (48 cm) long. The connecting pipe is about 12 in. (30 cm) long.

This work was done by Mukesh K. Khattar of Florida Solar Energy Center for **Kennedy Space Center**. *For further information,* ***write in 21*** *on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 4,971,139). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Kennedy Space Center [see page 22]. Refer to KSC-11395.

Acoustic Pump

Acoustic-radiation pressure is used instead of moving parts.

Langley Research Center, Hampton, Virginia

A pump uses acoustic-radiation forces, instead of conventional moving parts, to transfer momentum in a way that results in the flow of the sound-propagating material. Conventional pumps fall into two classes: positive-displacement pumps, such as piston pumps, which work on the principal of compression of the material; and force pumps, such as the familiar blade pump, the screw pump, and the impeller or turbine pump. All of the conventional pumps require moving parts. They are complex and subject to wear and can contaminate their environments, cause vibration, induce vortex flow, and fail in catastrophic fashion.

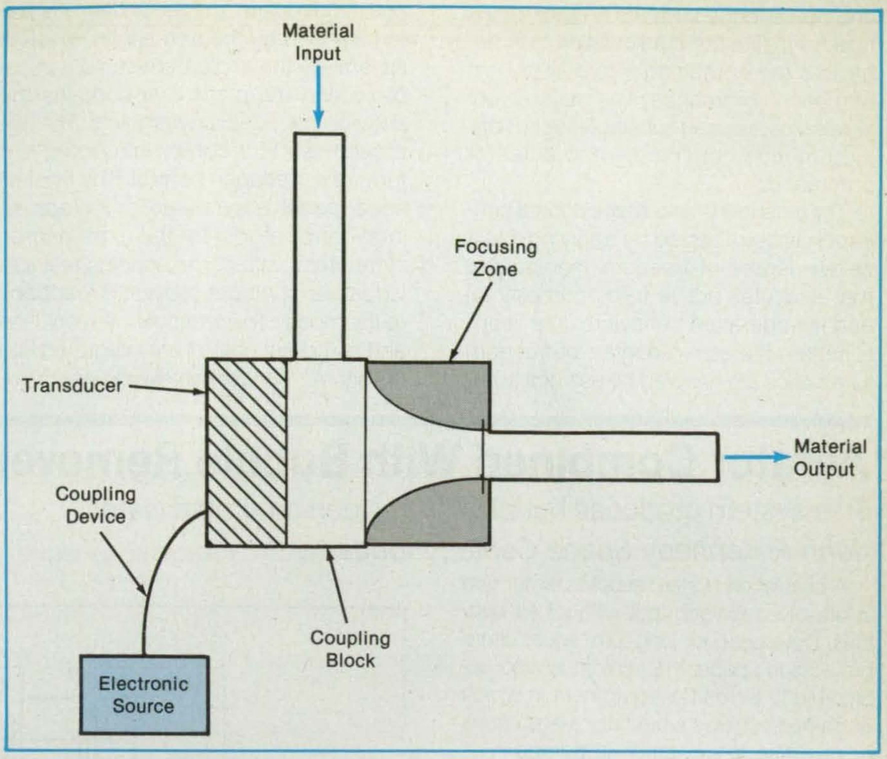
The acoustic pump is based on acoustic-radiation pressure. It relies on the interaction of acoustic energy along a propagation path to cause a radiation pressure that creates a force on the pumped medium. The pump illustrated in the figure includes a device that focuses the acoustic energy to increase the interaction with the

medium. The transducer is excited by an electronic source via the coupling device so as to interact with the pumped medium, which enters from the material-input device. The coupling block accepts the flow of the material and directs it through the focusing zone, from which the material flows through the material-output device.

In this design, the focusing zone maintains a high energy density to reduce the total path length needed to achieve the net radiation interaction. As the energy density increases, the nonlinearity of the medium begins to favor the generation of harmonics, resulting in the propagation of significantly higher frequencies and in higher absorption.

The coupling block can also act as an acoustic lens in combination with a transducer of modified surface geometry. In that case, the acoustic beam entering the focusing zone can have a shape identical to that of the focusing-zone cavity, resulting in no loss of acoustic energy to the walls of the cavity. This design would increase the efficiency of the device, ensuring that all acoustic losses remain in the pumped material.

The acoustic pump is a solid-state pump. It requires no moving parts, can be entirely miniaturized, and does not invade the pumped environment. It is silent, with no conventional vibration. It can be used as a pump for liquid, suspension, gas, or any other medium that interacts with radiation pressure. It could be used where a solid-state pump is needed for reliability and controllability. In a microgravity environment, where the gravitational effects of density are nearly zero, this device would offer unusual control for low flow rates. For medical or other applications in which contamination cannot be allowed, this device offers a noninvasive pumping force. Because there are no moving parts, this device is uniquely capable of easy miniaturization to sizes below those possible with conventional mechanical pumps.



Momentum Is Transferred from sound waves to the sound-propagating material in a way that results in a net pumping action on the material.

This work was done by Joseph S. Heyman of **Langley Research Center**. *For further information,* ***write in 91*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 22]. Refer to LAR-14103.

Extended-Task-Space Control for Robotic Manipulators

No differentiation between redundant and nonredundant manipulators is made at the task level.

NASA's Jet Propulsion Laboratory, Pasadena, California

The extended-task-space concept for the supervisory control of several robotic manipulators represents a synthesis of several older manipulator-control concepts into a more general control concept. The extended-task-space concept provides a unified approach for the control of both redundant and nonredundant manipulators: a theoretical framework for a complete description of a set of mechanism commands (usually, joint-torque and joint-angle commands) in terms of task-space commands (usually, commanded trajectories and commanded forces exerted on objects), and a singularity-avoidance scheme that provides robustness at and near singular points of the workspace while not degrading performance in the nonsingular regions.

Previously, the control of redundant manipulators and the control of nonredundant manipulators were approached differently. In prior redundant-manipulator-control schemes, task-space control was segregated from resolution of redundancy. Task-space control coordinates did not span all mechanical degrees of freedom. The switching prevalent in these schemes caused unnecessary computational complexity and undetectable additional singularities. In prior impedance-control approaches, all inputs in the case of a given manipulator were in the same frame of reference, limiting task-execution capability where the manipulator was redundant.

As its name suggests, extended-task-space control is based partly on the notion of the extended task space, which is the space of all currently active behaviors of the manipulator: The control of each behavior is unique and takes place in a unique space; e.g., active compliance may take place at a gripper, while a commanded trajectory may be executed at the hinge of a door. Each behavior is characterized by configuration parameters that determine precisely its operation and the use of real and virtual sensor data. Virtual sensors are those that derive data, possibly from real sensors; e.g., a joint-limit or singularity sensor derives data from real joint-position sensors.

Because the extended-task-space control coordinates span all mechanical degrees of freedom of the manipulator, the mapping from the task space to the actuator space can incorporate such a priori information as data on regions that contain singularities. In addition, a priori maps are provided to generate virtual force fields that make the manipulator tend to avoid singular regions of the workspace. Tradeoff tracking and singularity avoidance occur only near singularities, and impedance control is extended to provide multiple behaviors for redundant robots, each in its own behavior space.

No differentiation between redundant

and nonredundant robots is made at the task level, and the manipulation task behaviors are combined into a single set of motion commands. The manipulator kinematics are used subsequently in mapping motion commands into actuator commands.

The extended-task-space control concept has been tested by applying it to a seven-degree-of-freedom manipulator that executes active force/compliance and teleoperation behaviors. In this application, the seven-degree-of-freedom kinematics are handled by use of a composite Jacobian. The redundancy is parameterized by the arm angle, which is essentially the angle between a vertical plane and the plane that contains the shoulder, elbow, and wrist joints. The approach used for compliant control is a form of impedance control. The impedance model is extended to include an impedance model for the extra degree of freedom, with corresponding real and virtual sensor input providing feedback to the model. The redundancy-resolution and compliant control are integrated into the shared-control framework, which enables the integration of real and virtual sensors into a single control framework.

This work was done by Paul G. Backes and Mark K. Long of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 14*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office–JPL [see page 22]. Refer to NPO-18902.

Aerator Combined With Bubble Remover

This system produces bubble-free oxygen-saturated water.

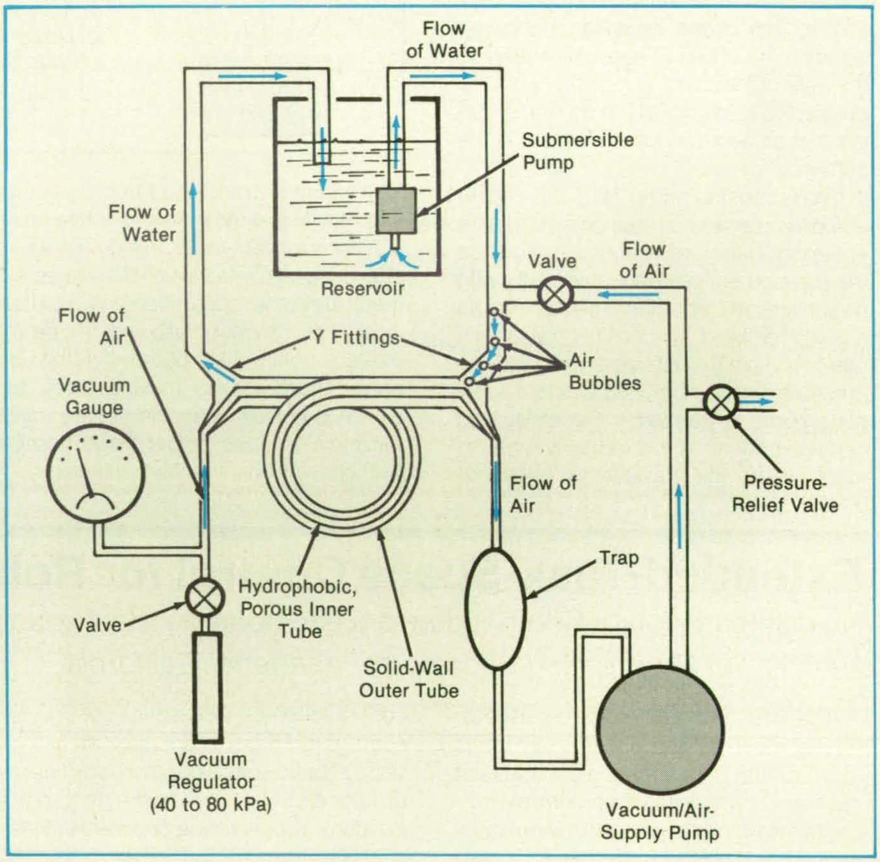
John F. Kennedy Space Center, Florida

A circulation system supplies water rich in dissolved oxygen, but without air bubbles. Developed for long-term aquaculture projects in space, the system is also applicable to terrestrial equipment in which entrained bubbles would dry membranes or give rise to cavitation in pumps.

A submersible pump in a reservoir pushes water past a valve that mixes pumped air into the flowing water (see figure). The air-laden water moves on to the bubble remover, which consists of an inner tube of hydrophobic porous tetrafluoroethylene and a coaxial outer tube of solid Tygon (or equivalent) polyvinyl chloride. As the water flows through the space between the tubes, air bubbles migrate through the wall of the porous inner tube into the inner channel, where they are drawn away by a vacuum/air-supply pump. At the regulated suction used (40 to 80 kPa), the hydrophobic nature of the porous inner tube keeps water from penetrating it. The bubble-free water returns to the reservoir. The vacuum/air supply pump returns the extracted air to the air injector.

In a prototype that contains a total of 2 liters of water, the concentration of dissolved oxygen increases from 3.4 mg/L to 4.4 mg/L during the first 5 minutes of operation. Within an hour, the concentration of oxygen stabilizes at 8 mg/L, near saturation.

This work was done by Thomas W. Dreschel of The Bionetics Corp. for **Kennedy Space Center**. *For further information,* ***write in 41*** *on the TSP Request Card. KSC-11554*



The **Bubble Remover** consists of an outer solid-walled tube and an inner hydrophobic, porous tube. Air bubbles pass from water in the outer tube into the inner tube, where they are sucked away.

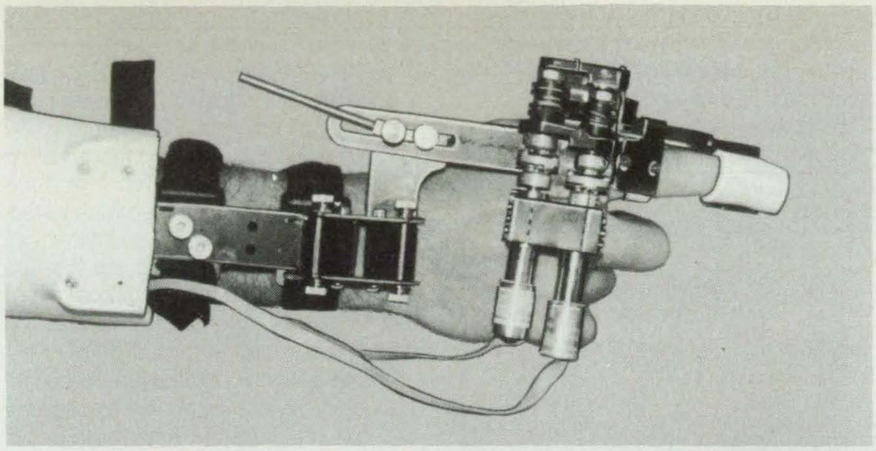
Sensing and Force-Reflecting Exoskeleton

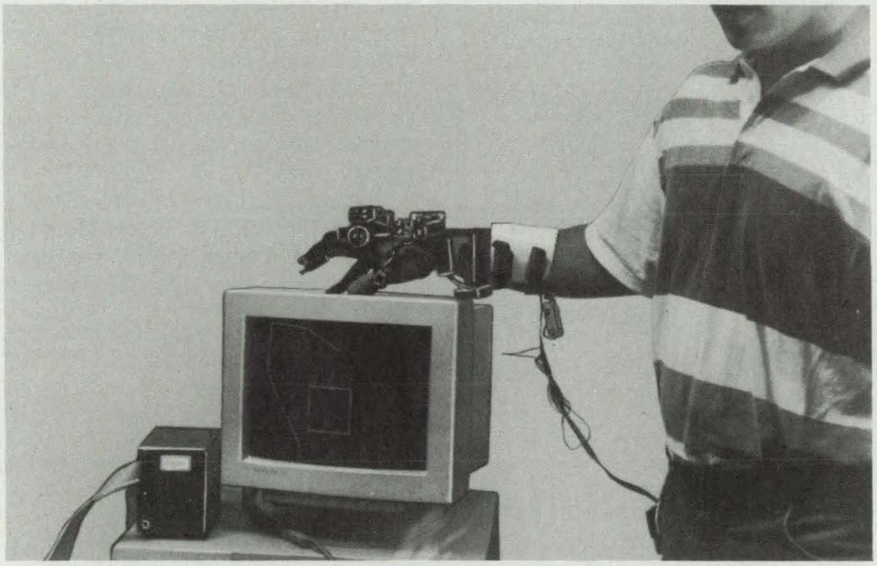
The wearer can control a robot hand and feel forces on the robot hand.

Marshall Space Flight Center, Alabama

The sensing and force-reflecting exoskeleton (SAFiRE) provides control signals to a robot hand and force feedback from the robot hand to a human operator. By use of the SAFiRE, the operator can make the robot hand touch objects gently and manipulate them finely without exerting excessive forces.

The SAFiRE is a precise sensing and torque-generating device that is attached to the operator's hand (see figure); it is comfortable and lightweight. It includes a finger exoskeleton, a cable mechanical transmission, two dc servomotors, a partial thumb exoskeleton,





The **Sensing and Force-Reflecting Exoskeleton** enables the wearer to control a robot hand without applying excessive forces to manipulated objects.

a harness, an amplifier box, two computer circuit boards, and software. It transduces the motion of the index finger and thumb. The video monitor of an associated computer displays an image that corresponds to the motion. The computer calculates intersections of the index-finger image with an obstacle and commands the SAFiRE to generate forces on the index finger when there is an intersection between the finger and the obstacle.

The novel features of the SAFiRE lie in the exact choice of linkage kinematics, reduction ratios, and structure, which provide low inertia, low friction, significant forces, finger measurement with minimum number of sensors, no singularities, and simple kinematic computation. The method of attaching comfortably with a minimum number of attachment parts is also unique. The linkage will fit both large and small hands with a minimum amount of adjustment and accommodates the natural small motions of the joint centers without inducing errors or discomfort.

This work was done by Brian Eberman, Richard Fontana, and Beth Marcus of EXOS, Inc., for **Marshall Space Flight Center**. *For further information,* ***write in 12*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 22]. Refer to MFS-26194.

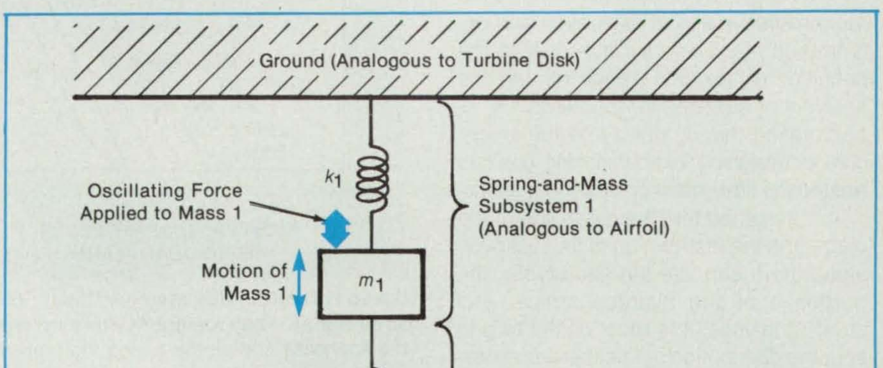
Tuned-Mass Damper for Turbine Blades

Resonances are altered to suppress vibrations.

Marshall Space Flight Center, Alabama

A damping ring has been designed to suppress fundamental-bending-mode vibrations of the blades on an integrally bladed turbine rotor. The damping ring and turbine blades behave analogously to the two-mass, two-spring system, shown in Figure 1, that is often cited in teaching the basic principles of coupled oscillating subsystems. The classical analysis of this well-known system shows that the two springs and two masses acting together exhibit resonances different from those of the individual spring-and-mass subsystems.

The analysis also shows that by appropriate selection of the masses and the stiffnesses of the springs (or, equivalently, by selection of the ratio between the masses and the ratio between the resonant frequencies of the individual spring-and-mass subsystems), one can reduce the vibrational response of mass 1 to an applied oscillating force. For example, by choosing spring 2 and mass 2 such that the reso-



Figures 1. **Two Coupled Spring-and-Mass Subsystems** constitute a system that behaves according to well-known equations. The tuned-mass damping principle is based on this system.

nant frequency of this spring-and-mass subsystem equals the frequency of the applied force, one can, in principle, suppress completely the vibrational response of mass 1. (In practice, suppression is not complete, some frictional damping is also present, and tuning somewhat off resonance is usually preferable.) This is the basis of the tuned-mass damping concept.

In applying this concept to the turbine, the subsystem that consists of spring 1 and mass 1 represents a turbine blade, while the subsystem that consists of spring 2 and mass 2 represents the associated part of the damping ring. The damping ring is 1 piece, with 42 standups (1 for each of the 42 turbine blades), such that the damping ring acts as 42 separate tuned-mass dampers. The ring is positioned, as shown in Figure 2, to suppress the fundamental (fore-and-aft) bending mode of each blade. A slightly tight fit retains the damping ring on the rotor disk.

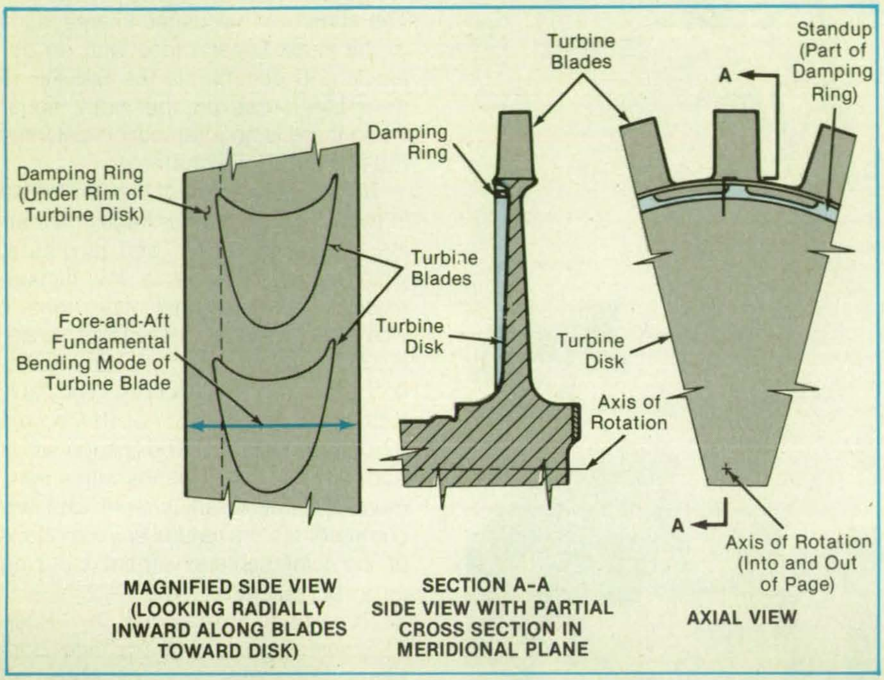


Figure 2. The **Damping Ring** acts as a set of tuned-mass dampers that suppress fore-and-aft vibrations of the turbine blades.

In one design, for example, the resonant frequency of vibration of each blade alone is 6 kHz, the mass of the damping ring is ¼ that of all the blades, and the resonant frequency of each segment of the ring between a pair of standups is 4.8 kHz. The standup under each blade enforces a local node of zero motion in the plane of the fundamental bending mode, thereby absorbing vibrations.

This work was done by John J. Marra of United Technologies Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 8*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 22]. Refer to MFS-28697

Simplified Computation of Blade-Surface Coordinates

This method reduces the time spent on design iterations.

Marshall Space Flight Center, Alabama

Coordinates of points on the complicated three-dimensional surface of a turbomachine blade can be computed by a method that partly simplifies the three-dimensional problem to a two-dimensional problem. The method has been implemented in a computer program that enables the rapid hydrodynamical evaluation and optimization of a blade surface prior to the definition of the final design of, and the analysis of stresses in, the blade. By incorporating this program into the procedure for designing a turbomachine, one can reduce the time spent on design iterations.

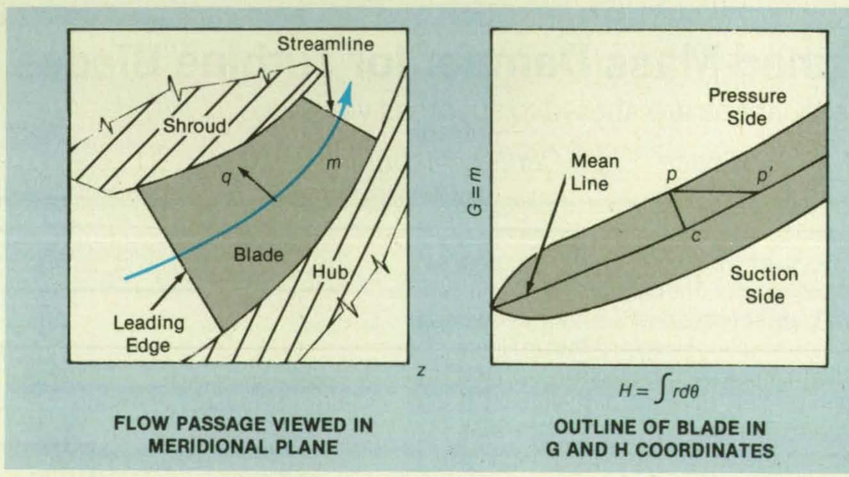
It is assumed that the mean line of the blade and the distribution of its thickness along the mean line are known. For the purposes of the hydrodynamical and stress analyses, it is most useful to present the distribution of thickness in cross-sectional surfaces of revolution formed by streamlines. One set of coordinates (see figure) that is particularly appropriate for such a surface is defined as follows:

$$G = \int dm$$

and

$$H = \int r d\theta$$

where dm is the increment of distance in the projection, upon a meridional plane, of an increment of a streamline; r is the radial distance of the streamline from the axis of symmetry of the machine in conventional cylindrical coordinates; and $d\theta$ is the increment in the azimuthal angle, in the conventional cylindrical coordinates, of the increment of the streamline. Thus, G is a quasi-axial coordinate and H is a quasi-azimuthal or circumferential coordinate in a surface of revolution defined by streamlines.



G and H Coordinates are curvilinear coordinates in a surface of revolution defined by streamlines. They are shown here in relation to the streamwise coordinate m ($G = m$), the spanwise coordinate q, and the conventional radial and azimuthal coordinates r and θ.

The G and H coordinates of points on the surface of the blade in a given flow surface of revolution are computed as follows:

1. Compute the G and H coordinates of points along the given mean line.
2. Compute the G and H coordinates of the surface points that correspond to the mean-line points by use of the specified thickness perpendicular to the mean line.

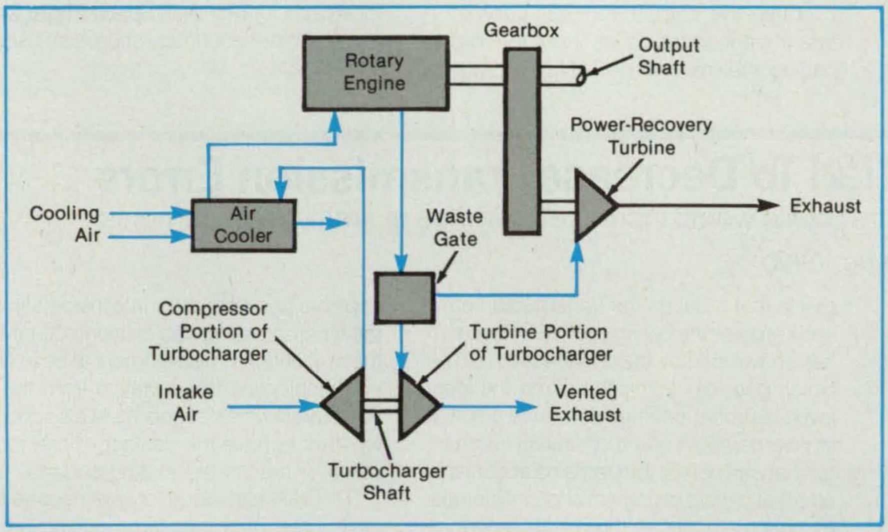
3. From a point p on the pressure side that is constructed from point c on the mean line, draw a line of constant G and find p', the intersection of this line with the mean line.
4. Find the G and the z (where z is the distance along the cylindrical axis in conventional cylindrical coordinates) of point p'.
5. Use the same G and z for point p.
6. Calculate the θ of point p. Once r, z, and θ are known, point p is completely defined.
7. Move to another point on the mean line, and repeat steps 1 through 6. Do this for all points along the mean line until the pressure side is completely defined.
8. Repeat the procedure on the suction side.

This work was done by Wei-Chung Chen, John V. Galazin, and Anthony H. Eastland of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 51*** *on the TSP Request Card.* MFS-29875

Engine Would Recover Exhaust Energy More Efficiently

Exhaust energy would be used for supercharging and extra shaft power.

Lewis Research Center, Cleveland, Ohio



The **Flow of Exhaust** would be apportioned by the waste gate to meet the demand of the turbocharger, and the portion not fed to the turbocharger would be sent to the power-recovery turbine. This scheme is expected to increase fuel efficiency.

In a proposed turbocompound rotary engine, a waste gate would route a portion of the exhaust gas to a turbocharger and the rest to a power-recovery turbine (see figure). Heretofore, in a typical engine system of this type, either a power-recovery turbine was placed directly in the one and only exhaust path or else the portion of exhaust not used by a supercharger would be vented to the atmosphere.

The waste gate in the proposed engine would be adjusted so that the flow of exhaust to the turbine portion of the supercharger would be sufficient to ensure an adequate supply of air to the engine at its current speed and load. The portion of exhaust gas not needed by the turbocharger would be bypassed to the power-recovery turbine, which would extract energy from the exhaust and return the energy to the output shaft of the rotary engine. The waste gate would thus provide efficient management of exhaust energy, some of which would otherwise have to be released to the atmosphere. It would route as much gas to the turbocharger as it needs at a given moment, but would make sure that gas unneeded by the turbocharger is put to good use.

This work was done by Philip M. Dimpelfeld of John Deere Technologies International, Inc., for **Lewis Research Center**. *No further documentation is available.* LEW-15205

Computing Shapes of Cascade Diffuser Blades

Optimum configurations are derived from a data base.

Marshall Space Flight Center, Alabama

A computer program generates sizes and shapes of cascade-type blades for use in axial or radial turbomachine diffusers. The optimum design of a cascade-type dif-

fuser or nozzle requires the evaluation of a large number of cascade data. The optimum design of blades for given inlet and discharge flow angles depends on the solidity, stagger angle, and camber angle of the blades. In the case of radial blades, the design problem is complicated further in that once the design is completed, the blade geometry must be transformed into the radial plane.

Previously, the design of a blade was completed by using the cascade data available in the literature, generating the shape of the blade, and then running other analysis codes to determine whether the blade would work as intended. The profile of the blade was then iterated to determine the optimum blade geometry. The number of different designs that could be evaluated was limited by the difficulty in generating the blade geometry and relating it to the data in the literature.

The present computer program generates the shapes of cascade-type blades rapidly. The program incorporates extensive cascade data to determine the optimum incidence and deviation angle for the blade design based on the 65-series data base of the National Advisory Commission for Aeronautics and Astronautics (NACA). The program allows great variability in blade profile through the input variables. These variables include the number of blades, inlet and discharge flow angles, blade solidity, type of distribution of thickness of a blade (e.g., elliptical, circular arc, and the like), location of maximum thickness, fairing of the thickness distribution, and maximum thickness. The program also provides for the design of three-dimensional blades by allowing variable blade stacking. The program uses these inputs to calculate the optimum incidence and deviation angles and then the size and shape of the blade. The program enables the designer to obtain the computed blade-geometry data in various forms: as input for blade-loading analysis (via the PANEL computer code), as input for quasi-three-dimensional analysis of flow (via the R3DAP computer code), or as points for transfer to computer-aided design.

The program has been used to design an axial diffuser for the National Launch System (NLS) fuel turbine and for the design of a radial cascade-type diffuser for the National Aero-Space Plane (NASP) wide-flow-range-technology task. A better design for each diffuser is expected because of the large number of design iterations made possible by the use of the program. Another advantage is that the output of the program is set up to be used directly by other analysis codes so more time can be spent in optimizing the design and in using the various analysis codes than in creating input.

This work was done by Ken Tran and George H. Prueger of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*
MFS-29894

Helical Gears Modified To Decrease Transmission Errors

Slight deviations from the involute profile would increase tolerance of small misalignments.

Lewis Research Center, Cleveland, Ohio

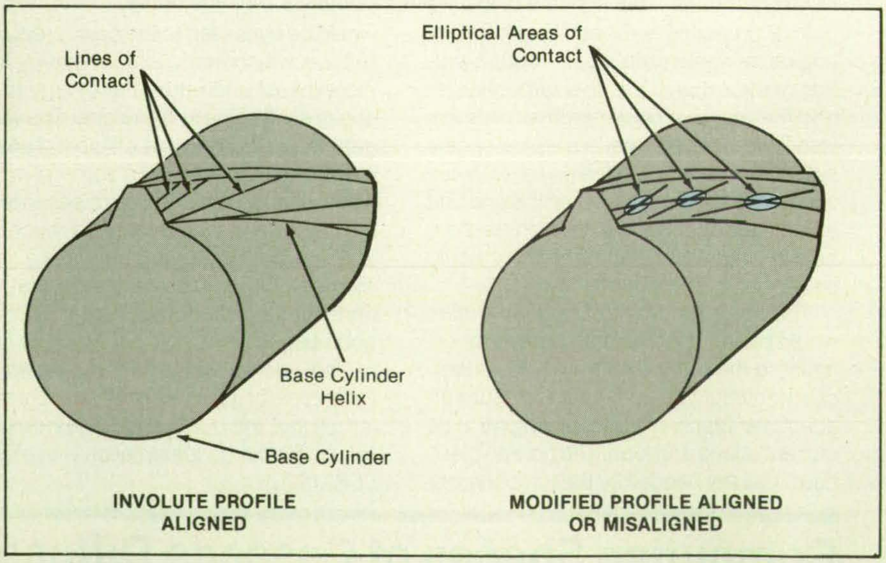
The tooth surfaces of helical gears would be modified, according to a proposed design concept, to make the gears more tolerant of misalignments and to improve the distribution of contact stresses. The modified gear designs could result in smaller transmission errors, with concomitant decreases in vibrations and noise and, possibly, increases in service lives.

Conventional helical gears are designed to have involute profiles, which yield perfect, smooth meshing along contact lines if the gears are perfectly aligned and are assumed rigid. However, performance can be degraded significantly when the axes of such otherwise ideal gears become even slightly misaligned (i.e., skew or intersecting instead of parallel). Misalignment transforms contacts from lines to points of concentrated stress, and transmission errors appear; that is, the rotation of the output gear contains small linear-saw-tooth angular vibrations, at the frequency of meshing of the gear teeth, about the nominal smooth rotation.

The proposed design concept exploits recently developed capabilities for the computation of tooth-contact analysis for non-ideal gear teeth. From the outset, the design analysis takes account of both misalignment and the elastic yielding that occurs in the high-stress contact areas of real teeth. In this analysis, it is recognized that the elastic yielding transforms the contact point into a contact ellipse (see figure). (In the rare case of perfect alignment of nominally involute gears, the contact ellipse becomes elongated into a contact strip.)

The problem is to design a modified tooth profile that reduces the transmission error and improves the bearing contact. Research has shown that by making the teeth of the pinion gear deviate slightly from the ideal involute profile, one can introduce a softer, smaller parabolic-saw-tooth transmission error that can persist (but remains acceptably small) at perfect alignment and that increases only gradually as the misalignment increases. The designer must select the acceptable parabolic error in consideration of the types (crossing and/or intersecting) and the amount(s) of misalignment to be tolerated. In selecting the deviation from the involute profile, the designer must also choose whether to have the contact ellipse move along or across the mating surface.

The best technique for making a helical pinion gear that has the modified profile depends on the specific problem. For ex-



A **Helical Gear** that has an involute profile that is assumed to be rigid and aligned with another such gear makes contact with the other gear along a series of lines. If misalignment occurs, the contact is shifted to the tooth edge and is accompanied with large, undesirable transmission errors. A modified gear profile makes contact on an elliptical area and exhibits transmission errors that are considered in the design process. The proposed, modified profile-design concept takes into account the expected misalignment and deformation at the contact to reduce the level of transmission errors that would have appeared with a standard involute profile.

ample, a large involute pinion could be reground to the new profile. Alternatively, the modified pinion could be cut anew by computer-controlled machining or by conventional machining with a modified rack-gear cutter.

This work was done by R. F. Handschuh and J. J. Coy of **Lewis Research Center** *and F. L. Litvin and J. Zhang of the University of Illinois. Further information may be found in NASA TM-102134 [N89-28015], "Topology of Modified Helical Gears."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703)487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LEW-15048

Strong, Ductile Rotor for Cryogenic Flowmeters

Small amounts of magnetic alloy are placed at tips of blades.

Marshall Space Flight Center, Alabama

An improved magnetic flowmeter rotor resists cracking at cryogenic temperatures, yet provides an adequate signal to the magnetic pickup outside the flowmeter housing. Previously, flowmeter rotors were typically made of stainless-steel alloy 430, solenoid grade. Although magnetic, this material becomes brittle and tends to crack in liquid oxygen. In addition, this alloy is subject to embrittlement by hydrogen.

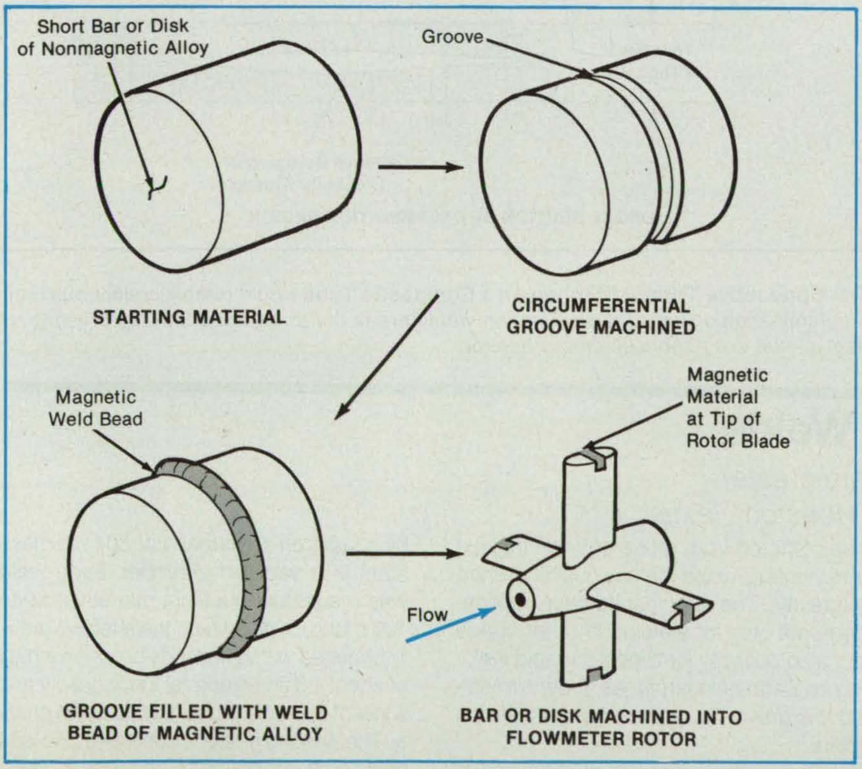
The improved rotor consists mostly of stainless-steel alloy 347, which is ductile and strong at low temperatures. However, alloy 347 is nonmagnetic. Therefore, a small bead of stainless-steel alloy 410 is welded in a groove around the circumference of a round bar of stainless-steel alloy 347; then the rotor is machined from the bar (see figure). As a result, the tips of the rotor blades contain small amounts of the magnetic alloy, and the passage of these tips can be detected by a magnetic pickup outside the flowmeter housing.

The improved rotor has been operated in high-pressure flowmeters for liquid oxygen and nitrogen for several months. No signs of cracking have been found in nondestructive examinations.

Because the magnetic bead of alloy 410 is severely embrittled by hydrogen, another version of the rotor was made for liquid-hydrogen flowmeters. In this version, the rotor is also machined from a rod of alloy 347, as before, but the magnetic inclusion is made of alloy NI 200, which, in comparison with alloy 410, is less vulnerable to embrittlement by hydrogen.

This work was done by W. T. Royals of United Technologies Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 3*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 22]. Refer to MFS-28675



A **Small Slot** is machined around the circumference of a rod. A bead of magnetic alloy is welded in the slot; then the rod is machined into the shape of the flowmeter rotor.

Stitched Conductive Threads for Monitoring Composite Parts

Cracks would be detected electrically while parts are in service.

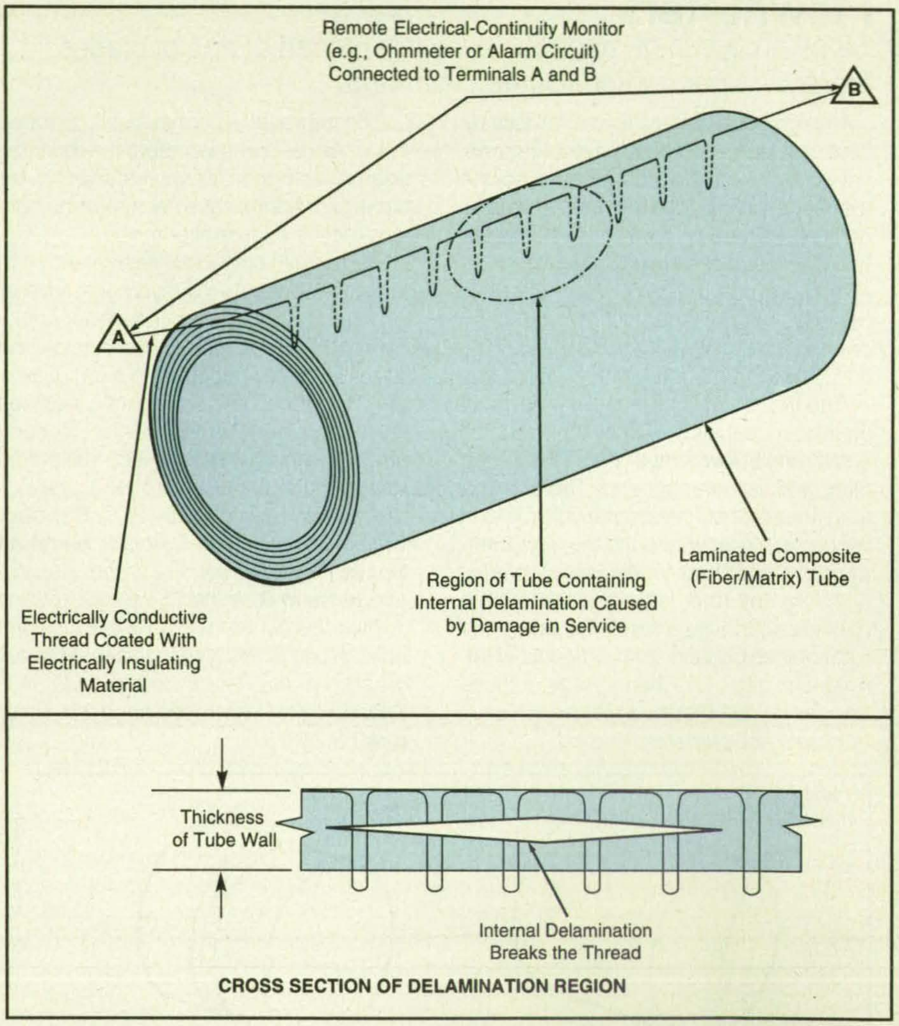
Lyndon B. Johnson Space Center, Houston, Texas

A proposed method of remote electrical-continuity monitoring would signal internal delaminations, cracks, and similar flaws in structural parts made of composite (fiber/matrix) materials. The method would entail only simple, cheap electrical monitoring equipment and a relatively small investment in manufacturing equipment. If delamination could be detected in its early stages by use of this method, it should be possible to repair or replace a structural part before it fails.

During fabrication, each structural part to be monitored would be tack-stitched with electrically conductive thread (see figure). (In the case of an electrically conductive composite part, the thread would have to be coated with an electrically insulating material.) Electrical connections to a conductive thread could be made at the locations where it comes to the surface. Any cracking or delamination in the stitched region would stretch or break the thread. The electrical resistance of the thread would be monitored regularly; a sudden increase in resistance would indicate a stretched or broken thread and hence a flaw in the structural part.

Stitching could be limited to regions of principal concern — for example, regions near notches or holes where stresses are concentrated. If threads were stitched in adjacent rows, the growth of a flaw could be monitored as one thread after another breaks.

This work was done by Howard S. Travis of Lockheed Engineering & Sciences Co. for **Johnson Space Center**. *No further documentation is available.* MSC-22116



The **Conductive Thread Stitched on a Composite Tube** would remain continuous until a delamination occurred. Delamination would break the thread and thereby present an open circuit to a remote electrical monitor.

Low Gravity Improves Welds

Hardnesses and tensile strengths are greater.

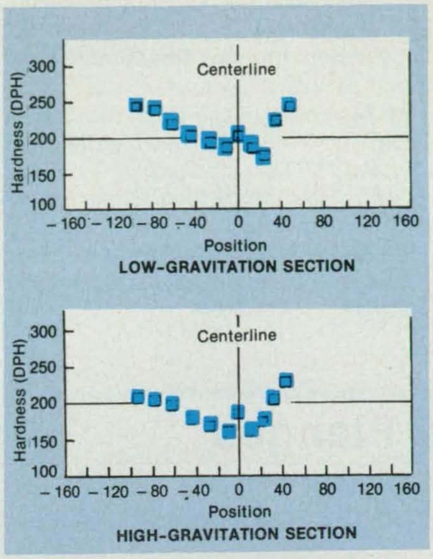
Lyndon B. Johnson Space Center, Houston, Texas

Welds made under the right conditions in low gravity appear to be superior to those made under high gravity. This conclusion has been drawn from the results of welding experiments conducted during low- and high-gravity-simulating maneuvers of a KC-135 airplane. Previous low-gravity welding experiments aboard the Skylab spacecraft yielded inconclusive results, partly because the experimental conditions differed from those of terrestrial experiments (beyond the obvious difference in gravity). The new results have implications not only for welding in outer space but also possibly for repeated rapid welding on Earth or in airplanes under simulated low gravity to obtain unusually strong joints.

In the experiments, conduction-limited welds about 1 in. (2.5 cm) long were made by a laser on specimens of 304 stainless steel in a vacuum chamber. Each weld was made during a flight maneuver 60 to 100 s long, during which the effective gravity changed within seconds between a high of about 1.8 times normal Earth gravity and a low of 0 to 0.01 times normal Earth gravity. The welding process continued and was monitored during these changes. The effective gravity was monitored also so that

the gravity at which each point on the weld bead was formed could be determined.

The welds were sectioned, polished, and examined metallographically. The sections were found to have differences in microstructure that were correlated with the different levels of gravity. Microhardness measurements showed that the heat-affected and fusion zones at the low-gravity position along each weld bead were harder than were the corresponding zones at the high-gravity position (see figure). At both low- and high-gravity positions, the fusion zone was found to be harder than was the surrounding heat-affected zone. From other studies, it is known that hardness is a measure of tensile strength. The data from these experiments and the relationship between hardness and tensile strength indicate that the fusion zones of the low-gravity parts of the welds were as much as 10 kpsi (69 MPa) stronger than are those of the high-gravity parts of the welds, which had tensile strengths of 80 to 90 kpsi (552 to 621 MPa).



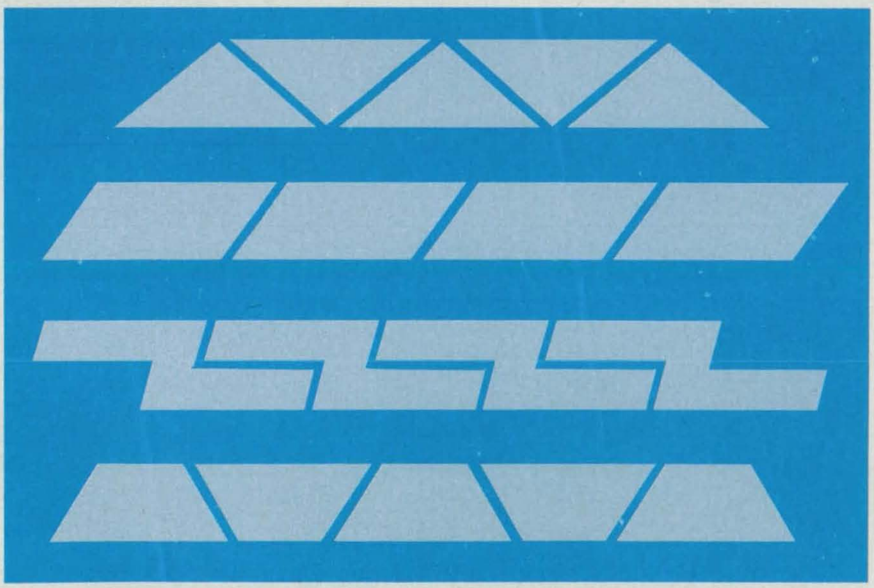
The **Diamond Pyramid Microhardness (DPH) as a Function of Position** across a weld is greater at the low-gravity end than at the high-gravity end of the same weld. The fusion zone is centered on the zero position.

This work was done by Gary L. Workman, William F. Kaukler, and Teresa C. Plaster of the University of Alabama in Huntsville for **Johnson Space Center**. *For further information,* ***write in 4*** *on the TSP Request Card.* MSC-21714

Alternative Cross-Section Towpregs for Robotic Layups

The angled cross-section helps composite ribbons to align themselves and correct adjacent tow gaps and overlaps.

Langley Research Center, Hampton, Virginia



These **Alternate Cross Sections** result in better packing of towpreg ribbons.

State-of-the-art robotic towpreg placement is capable of constructing large composite structures made of high-temperature performance thermoplastic matrix/carbon fiber towpreg ribbon. One key limitation of this automated process is the occurrence of incidental gaps and overlaps of adjacent towpreg ribbons as the robotic arm pays them out and adheres them to the part surface. These intraribbon misalignments often result in voids in the finished composite part. A proposed process suggests that robotic placement processing improvements could be realized by altering the cross-sectional shape of these wide and flat ribbon materials. These new prepreg architectures (see figure) include

isosceles triangles, parallelograms, hexagons, and variations of trapezoids.

The contrast of an isosceles triangle to a flat ribbon cross-section offers insight into the concept. An unbalanced force on any of the three surfaces of such a towpreg caused by misalignment of one towpreg next to another would result in a lateral shift of the former. In this simple wedge configuration, the array of towpregs nest among adjacent neighbors and form a flat, gap-free layer.

The fabrication of alternate cross-section towpregs utilizes a novel processing technique which begins with drawing carbon fibers coated with powdered polymer matrix through an insulated melting oven. A variety of conical and heated rods provide flow of the melted polymer and alignment of the fibers. The final nip-station solidifies the polymeric towpreg into the mirror-image shape of the grooves of the matched rollers.

The resulting towpreg form is void-free (preconsolidated) and consistent in cross-section along its length. Additionally, this towpreg is manufactured without use of solvents which are typically used to enhance the prepregging melt-flow of highly viscous polymer matrix systems.

The concept and use of towpreg of alternate architecture for robotic production of large polymeric/carbon fiber composite structures is currently being evaluated by a major U. S. commercial aircraft manufacturer.

This work was done by Robert M. Baucom of **Langley Research Center** *and Donald A. Sandusky and Joseph M. Marchello of Old Dominion University. For further information,* ***write in 18*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 22]. Refer to LAR-14863.

Caps Seal Boltholes on Vacuum-System Flanges

Deformable, leak-prone gaskets are replaced.

Lewis Research Center, Cleveland, Ohio

Sealing caps have been devised for boltholes on vacuum-system flanges. The caps are used in place of leak-prone gaskets, and they provide solid metal-to-metal interfaces.

Figure 1 illustrates the old and new ways of sealing between a valve on a large vacuum tank and an access port for vacuum experiments or processes. In the old technique, compressible rubber gaskets are placed under the bolthead and between the flange on the valve and the flange on the port. With the older gasket seal, it is usually necessary to apply a putty around the assembly to suppress residual leaks. Because of the flexibility of the gaskets, it is not possible to obtain a rigid mount. Overtightening of any of the bolts distorts the gasket, skews the mounting, and often reintroduces leakage. Moreover, to prevent rapid thermal degradation of the rubber gasket material, it is necessary to limit the maximum temperature of the port to about 125 °C.

In the new technique, each sealing cap (see Figure 2) contains a square-cut circular groove in which an O-ring is placed. The caps are mounted on studs that protrude into the access ports, providing a positive seal around each bolthole. Each cap mates directly with the surface of the flange, in a solid metal-to-metal fit, with the O-ring completely captured in its groove.

The assembly is immune to misalignment, to leakage caused by vibration, and to creeping distortion caused by the weight of the port. Moreover, the O-ring material can be chosen for resistance to high temperature; with appropriate choice of material, the temperature can be raised to as much as 315 °C.

This work was done by Robert F. Roman of **Lewis Research Center**. *For further information,* ***write in 107*** *on the TSP Request Card.* LEW-14939

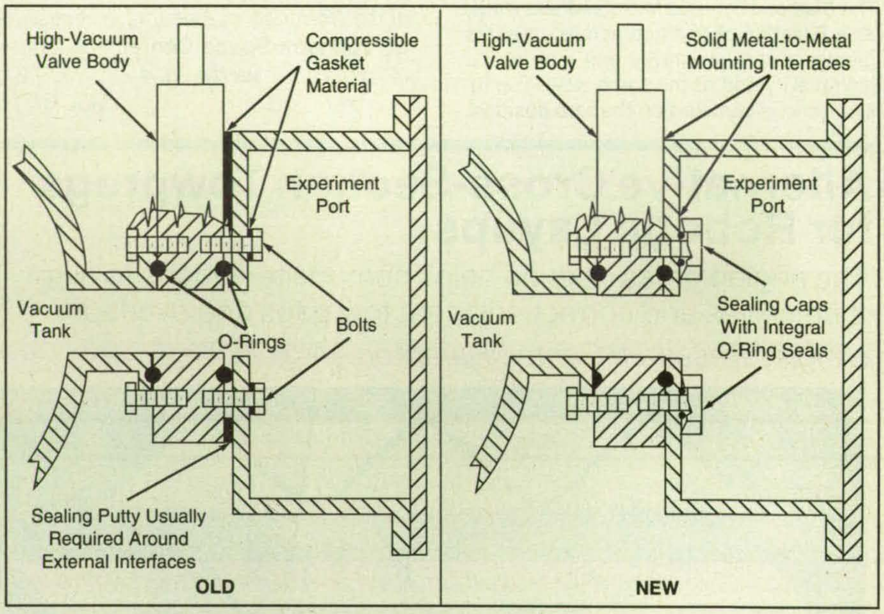


Figure 1. The **Connection Between a Valve and a Port** is subject to leakage and looseness when sealed the old way, with a large rubber gasket. The new technique, with O-rings in sealing caps, yields a more effective seal and a more-rigid mount.

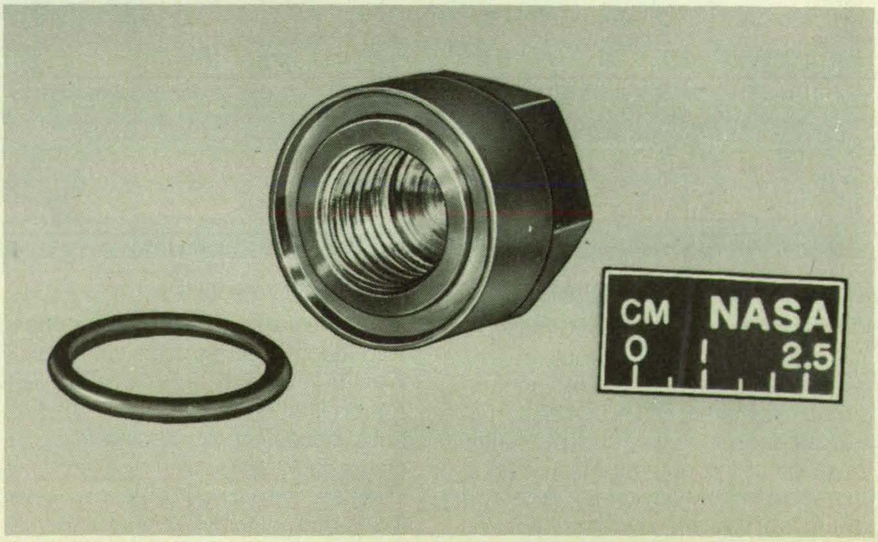
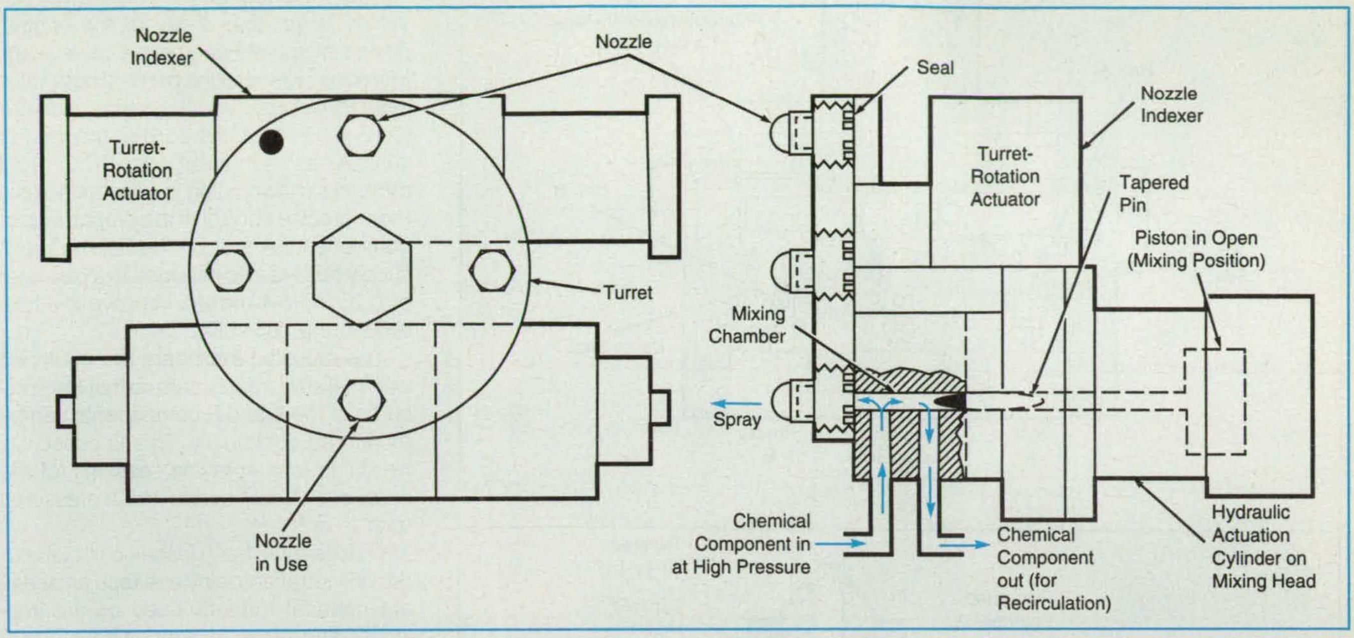


Figure 2. The **O-Ring** fits in the groove in the sealing cap.

Multiple-Nozzle Spray Head Applies Foam Insulation

When a nozzle becomes clogged, a turret is rotated to connect a clear nozzle.

Marshall Space Flight Center, Alabama



The Turret Head Turns through 90°, thereby indexing a replacement nozzle to the mixing chamber.

A spray head equipped with a four-nozzle turret mixes two reactive components of a polyurethane and polyisocyanurate foam insulating material and sprays the reacting mixture onto the surface to be insulated. If the nozzle in use becomes clogged, a fresh one is automatically rotated into position, with minimal interruption of the spraying process. The head also incorporates features that recirculate and control the pressures of the reactive components to maintain the quality of the foam by ensuring a proper blend at the outset.

The multinozzle turret head can also be used to spray other materials — for example, protective coats on or in ships, aircraft, and pipelines. It can also spray such reactive adhesives as epoxy/polyurethane mixtures. The components of the spray can contain solid-particle fillers for strength, fire retardance, toughness, resistance to abrasion, or radar absorption.

If a buildup of elastomer or foam in the gun starts to degrade the output and distribution of the spray, the spray head is closed momentarily. Closure of the head forces all mixed (and reacting) material into the nozzle. (This material is later removed with the nozzle.) Immediately after closure of the nozzle, the turret is rotated to turn clogged nozzle 90° away from the mixing chamber (see figure), bringing an uncontaminated nozzle into line with the chamber. When the control system detects that the new nozzle is in place, it reopens the head, and spraying continues. The change takes less than half a second.

The pressures — and hence the mixing ratios — of the components are controlled by a hydraulically actuated, tapered center pin in the orifice through which each component enters the mixing chamber. The axial movement of each pin varies the area of its orifice and is adjusted automatically to compensate for variations in the temperature, viscosity, and rate of flow. When spraying is terminated, the chemical components are automatically recirculated to their storage tanks.

This work was done by Joe T. Walls of Martin Marietta Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 61*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 22]. Refer to MFS-28660.

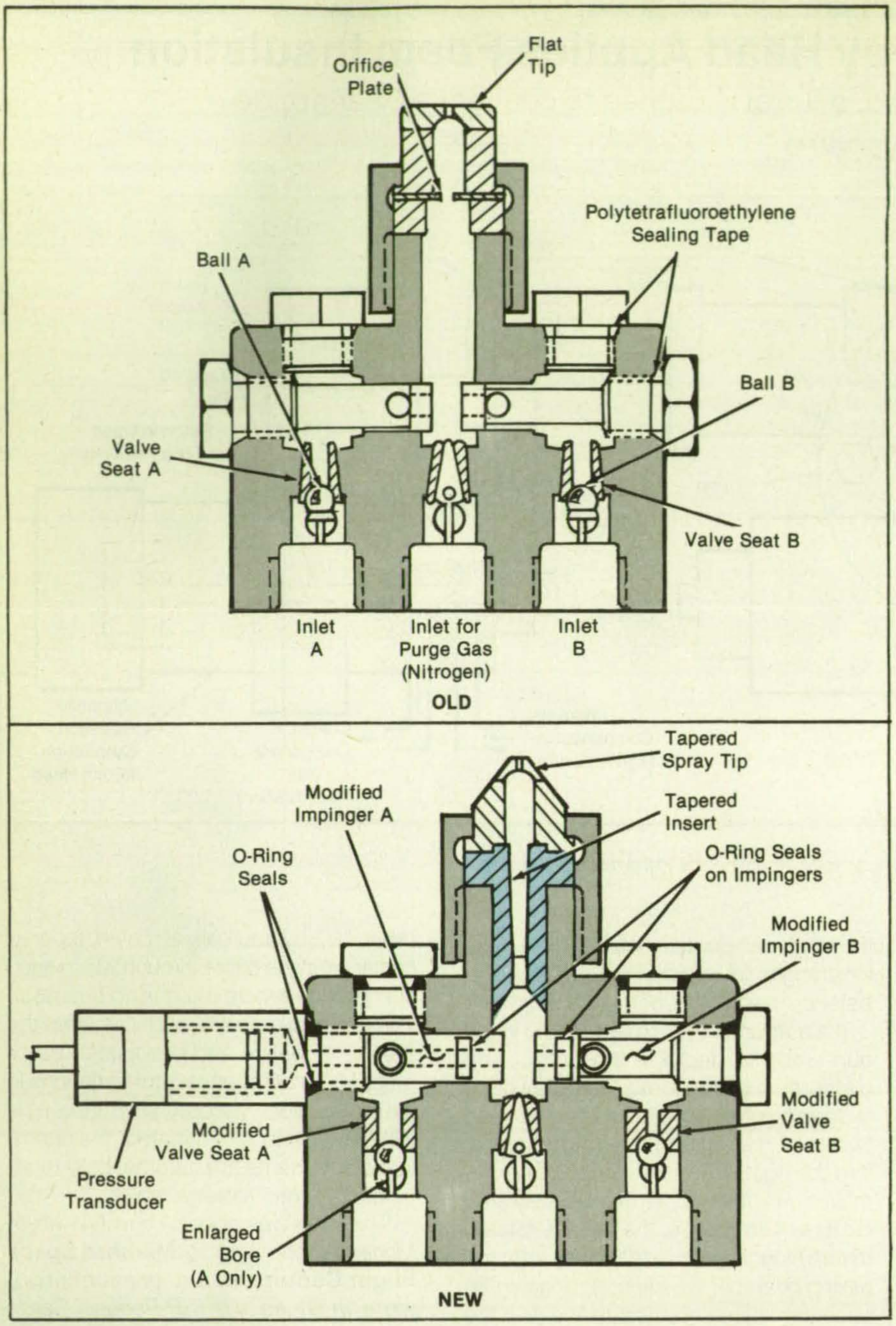
Modifications of a Commercial Spray Gun

The modifications are intended to increase capacity and consistency.

Marshall Space Flight Center, Alabama

A commercial spray gun has been modified to increase its spray rate and make the sprayed coats more nearly uniform. The spray gun consists of a gun head and pneumatic actuator. The actuator opens the valves for the two chemical components, called "A" and "B," that react to produce foam. The components flow through orifices, into a mixing chamber in the head. The mixture then flows through a control orifice to the spray tip.

The original version and one of the modified versions is shown in the figure. The new spray tip is tapered to reduce the area available for accumulation of foam and make the tip easier to clean. The benefits of this modification are expected to be a more nearly uniform layer of foam on the workpiece, reduction of the frequency with which the gun has to be cleaned, and elimination of external clogging. The sub-



The **Spray Gun Combines Chemicals,** A and B, that react to produce a solid foam. The modifications noted in the new version are intended to increase the rate of spray and the quality of the resulting coat.

stitution of a tapered nozzle insert for an orifice plate is intended to reduce the internal buildup of foam, thereby reducing the frequency of clogging and the consequent need for disassembly and internal cleaning.

The modified gun incorporates ball valves larger than those of the original design, along with new plastic valve seats. Moreover, whereas the bores of both valve seats previously had the same diameter [0.12 in. (3 mm)], the bore of the seat of valve A has been enlarged to 0.21 in. (5.3 mm); this modification is intended to give more precise control of the proportions of components A and B. The hole to the A supply hose is also enlarged to a diameter of 0.25 in. (6.4 mm) to improve the flow around the ball valve.

The modified impingers are equipped with pressure transducers so that the pressures of the A and B components can be monitored continually. This is especially helpful in long spraying sessions (of the order of an hour), during which pressures tend to drift.

O-rings have been installed in place of the polytetrafluoroethylene tape and sealant material formerly used on the impingers and plugs. The modified A and B valves are equipped with nylon sealing shims to accommodate manufacturing tolerances and provide for adjustment of the valve stroke.

This work was done by Peter B. Allen of Martin Marietta Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 88*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 22]. Refer to MFS-28661

Portable Device Slices Thermoplastic Prepregs

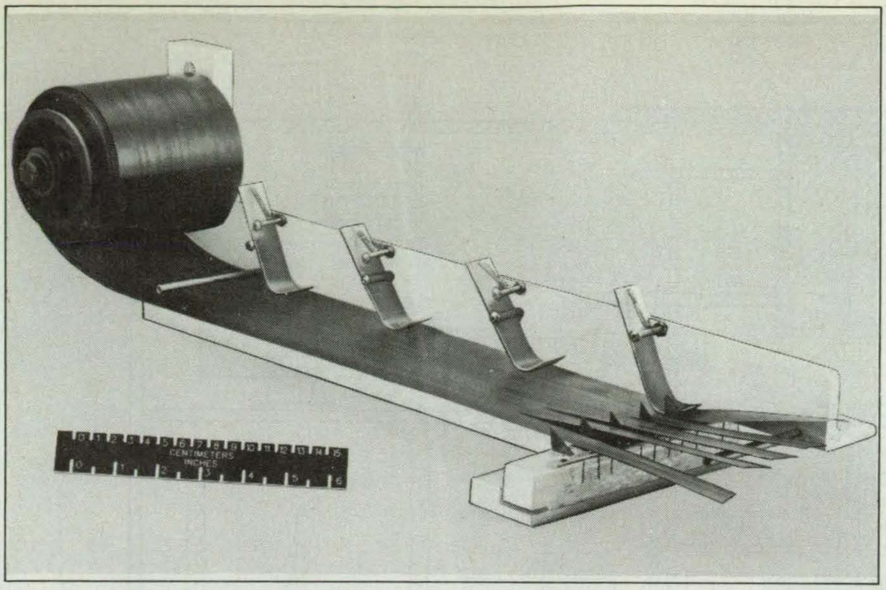
This device simplifies the slitting of uniaxial prepregs into various widths.

Langley Research Center, Hampton, Virginia

A portable slitter slices thermoplastic prepregs reinforced by unidirectional graphite fibers into strips of various widths. In the previous method of slitting, a prepreg was unrolled from a spool and laid on a cutting table, a hand-held straight edge was used to control the cutting line, and a razor blade was used to slit the prepreg. The slitting procedure consumed much time, and the maximum manageable length of prepreg was approximately 6 ft (1.8 m). However, prepregs for use in pultrusion are required to be sliced into strips up to several hundred feet (about 100 m) long. The portable slitter makes such long strips rapidly and accurately, with relative ease.

Prepreg is usually received in rolls ranging in width from 3 in. (7.6 cm) to 12 in. (30.5 cm). In preparation for pultrusion of such composite structures as airfoils, multiple plies of prepreg must first be sliced precisely to various specific widths. The prepreg slitter was designed to slit various widths rapidly by use of a slicing bar that holds several blades, each capable of slicing a strip of preset width in a single pass. The slitter produces material that is evenly sliced and that does not contain jagged edges, as was often the case in the previous method.

The portable slitter can be used for various applications in such batch processes



The **Portable Slitter** incorporates multiple blades to produce strips of several different widths simultaneously.

involving composite materials as press molding and autoclaving, and in such continuous processes as pultrusion. This slitter should be useful to all manufacturers of thermoplastic composites and could also be useful in slicing B-staged thermoset composites.

This work was done by Beverly A. Taylor, Morton W. Boston, and Maywood L. Wilson of **Langley Research Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 22]. Refer to LAR-14533.

Airborne Laboratory Apparatus Draws Glass Fibers

The apparatus records images and data under a variety of experimental conditions.

Marshall Space Flight Center, Alabama

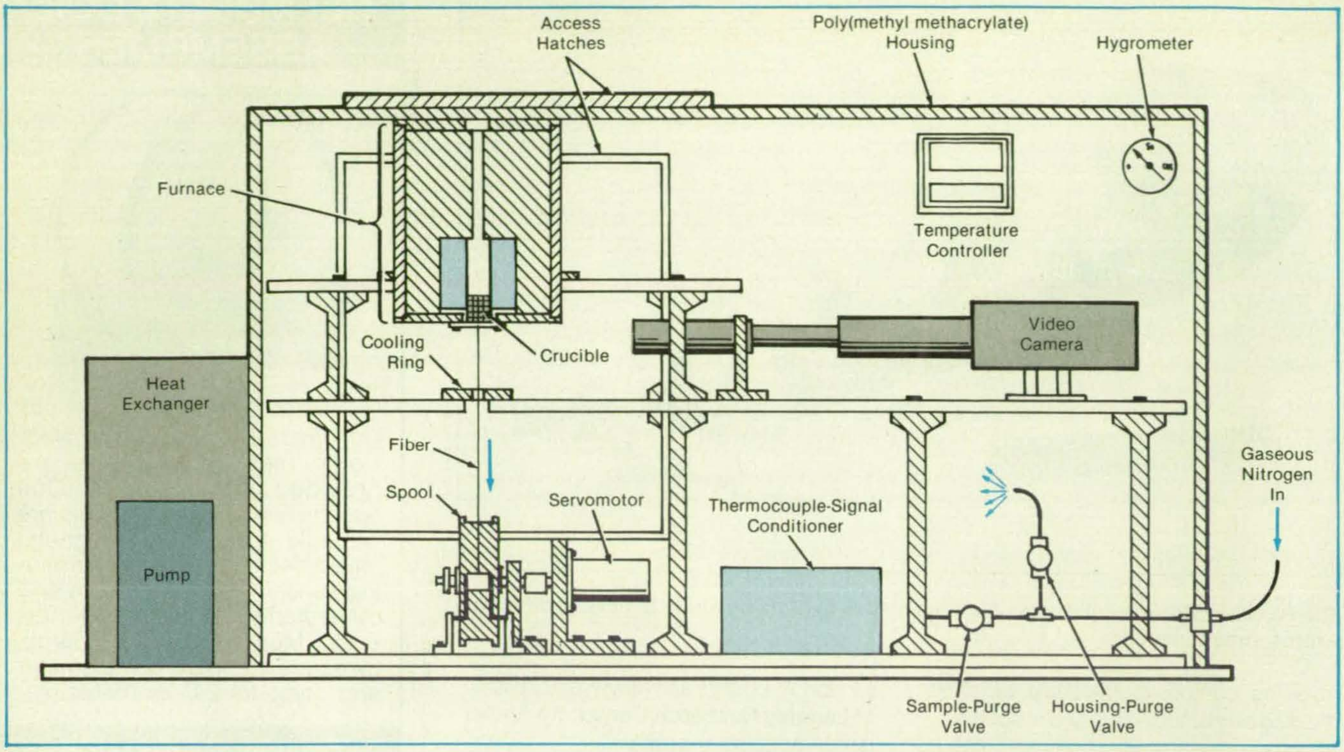
A glass-fiber-drawing apparatus is designed for studies of the effect of gravitation on the drawing process. Mounted in a research aircraft, the apparatus makes a continuous video recording of the formation of fiber at effective gravitational accelerations that range from 0.001 to 2 times normal Earth gravitational acceleration as the aircraft dives, then pulls out of dives. The apparatus also records pertinent process data on the video image.

The apparatus includes a crucible in a furnace, a ring to cool the glass fiber as it emerges from the crucible, a takeup spool, a video camera, and control instrumentation in a poly(methyl methacrylate) housing (see figure). A videotape recorder is located outside the housing, as is a pump and heat exchanger for the coolant liquid that is circulated through the cooling ring. A personal computer acquires data from the control instrumentation and controls the furnace temperature and the winding speed of the takeup spool accordingly.

At the beginning of an experiment, chunks of glass are added to the crucible. The temperature set point and ramp rate are programmed into the temperature controller, and the furnace is heated electrically by a resistive heating element. (The maximum temperature is 1,600 °C.) Dry nitrogen gas flows continuously through the apparatus, providing a low-humidity nonoxidizing environment.

During initial heating, the increments of the winding speed of the takeup spool are programmed on the computer. The maximum winding speed is 1,000 cm/s, and increments of the winding speed can be set from tenths of a centimeter per second to 100 cm/s. The technician presses an up or down arrow on the computer keyboard to increase or decrease the speed in increments.

Once the glass has melted and reached the required temperature (and thus viscosity), the technician uses a ceramic rod or large quartz fiber to



The **Clear Plastic Housing** surrounds fiber-drawing equipment and some of the associated electronic instrumentation. An external rack holds the video monitor, personal computer, keyboard, videotape recorder, and power switch panel.

draw a filament of the melt from an orifice in the crucible to the takeup spool. The operator sticks the end of the filament on a double-sided adhesive tape on the spool and starts the motor so that it continuously draws fiber from the melt. The melt temperature and takeup speed govern the diameter of the fiber.

The soft, partly molten fiber hardens rapidly as it passes through the cooling ring. The cooling ring is used at melt temperatures of 1,200 °C or more to ensure that the fiber is cool enough for winding when it reaches the takeup spool.

The video camera and recorder continuously observe and record the image of the emerging fiber. The computer simultaneously sends data to the recorder to be superimposed on the video image. Thus, alphanumeric characters that represent instantaneous accelerations along three orthogonal axes, melt temperature, and winding speed appear on the image. The technician can also record a vocal description of the experiment through a microphone.

This work was done by Dennis S. Tucker and Guy A. Smith of **Marshall Space Flight Center**. *For further information,* ***write in 106*** *on the TSP Request Card.*

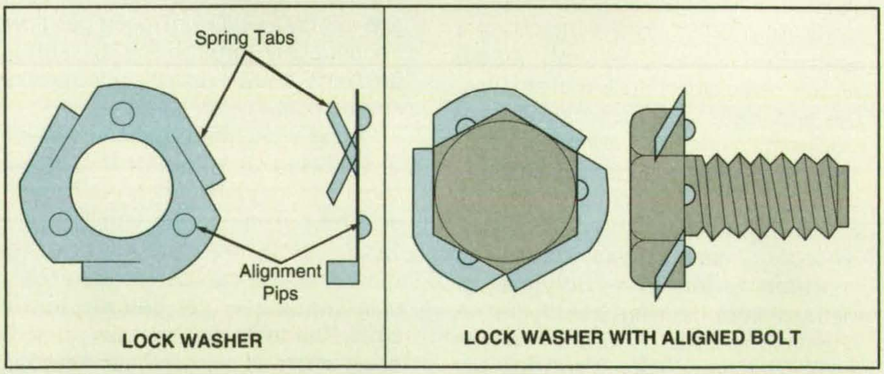
Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 22]. Refer to MFS-28712.

Spring-Tab Lock Washer

A washer holds a bolt or nut securely, with little damage to fastened parts.

Marshall Space Flight Center, Alabama

An improved spring-tab lock washer offers an alternative to such positive-locking devices as cotter pins and lock wires and to conventional split-ring lock washers. The installation of cotter pins and lock wires consumes significant amounts of time, and the reliability of lock wires, in particular, depends on the installer's skill. Unlike conventional split-ring lock washers, the improved spring-tab lock washer does not dig into the fastened parts with sharp edges; thus, it is less likely to inflict scratches that can cause cracks, which, in turn, can cause failures in highly stressed parts.



Spring Tabs on the Lock Washer allow only clockwise rotation (tightening) of a bolt or nut.

The improved spring-tab lock washer contains three winglike spring tabs and three alignment pips, which are pressed into mating dimples in the surface of a part to be fastened (see figure). It could probably be mass-produced by stamping from sheet metal. In preparation for the use of the improved spring-tab lock washer, the dimples could be formed in the part to be fastened by use of a suitable tool like a ball-end drill bit, possibly with the help of an alignment jig. Then the improved spring-tab lock washer is placed under the bolthead or nut in the conventional manner. As the bolt or nut is turned

to tighten it, the lock washer turns with it until the alignment pips settle into the dimples. Further tightening of the bolt presses the pips more firmly into the dimples.

As the bolt is turned, the corners of the rotating bolthead repeatedly pass over and flatten the spring tabs. After the corners pass over them, the tabs spring up against the sides of the bolthead, preventing any counterrotation. Thus, even if the bolthead is in a tab-flattening position when it is fully tightened, it cannot loosen more than one-sixth turn because in counterrotating, it backs into the tabs.

This work was done by Jeff Finckenor, Dylan Rogers, and Pete Rodriguez of **Marshall Space Flight Center**. *For further information,* ***write in 58*** *on the TSP Request Card.* *MFS-28722*

Saddle Clamp With Captive Components

Parts are easily reached and do not fall off.

Marshall Space Flight Center, Alabama

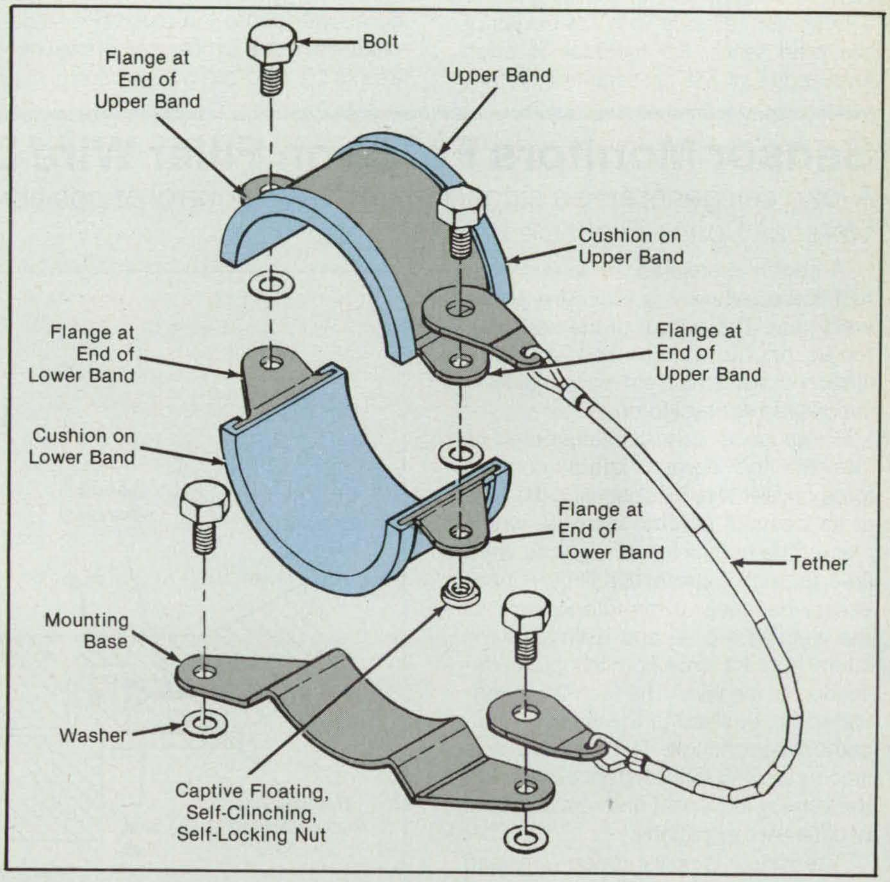
A saddle clamp has been modified to prevent parts from falling off when it is installed or removed. The clamp allows easy access for tightening or loosening bolts, and it retains its alignment with a tube mounted in it when it is opened.

The modified saddle clamp replaces a standard version that consists of seven loose pieces: two washers, two screws, two nuts, and the clamp body. It is difficult to align these parts during installation of the clamp, and parts often fall off and become lost in a maze of tubes during both installation and removal. It is difficult to realign a standard saddle clamp with the tube mounted in it, and if the clamp is twisted with respect to the axis of the tube, it could restrain the tube against thermal contraction and expansion, thereby causing the tube to break.

The modified saddle clamp includes upper and lower sections on a mounting base (see figure). The upper band of the clamp is tethered to the base, which remains bolted to a structure when the clamp is opened. The lower band is welded to the mounting base.

The upper section is secured to the lower section by a pair of nuts and bolts on flanges. The nuts are commercial floating, captive, self-locking, and self-clinching parts. They are pressed into the bottom of the lower section and swaged to prevent them from pulling out. The bolts are held captive by washers on the bottom side of the upper section.

Similarly, self-locking nuts are used on the bottom of the structure on which the clamp is mounted, and captive bolts are used to secure the mounting-base flanges to the structure. Because the mounting base remains bolted when the upper half is unbolted, the clamp retains its alignment with a tube mounted through it.



All Parts of the Saddle Clamp are held captive—bolts by retaining washers, floating nuts by pressing and swaging, and the upper clamp band by a tether. The upper and lower bolt flanges are offset from each other to ensure access.

The flanges on the upper and lower sections are offset from those on the mounting base. This arrangement ensures access to both sets of bolts.

This work was done by Charles R. Belrose of The Boeing Co. for **Marshall Space Flight Center**. *For further information,* ***write in 105*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquires concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 22]. Refer to MFS-28701.

Width Criterion for Weld-Seam-Tracking Data

Lines separated by insufficient or excessive gaps would be ignored.

Marshall Space Flight Center, Alabama

The image-processing algorithm in a "through-the-torch-vision" (T^3V) system that is being developed to guide a gas/tungsten arc welding robot along the weld seam would be modified, according to a proposal, to reduce the incidence of inaccurate tracking of the weld seam. The developmental system is intended to provide closed-loop control of the motion of the welding robot along the weld seam on the basis of lines in the T3V image that are identified by use

of an image-processing algorithm and that are assumed to coincide with the edges of the weld seam. The need for the modification of the image-processing algorithm arises because occasionally, lines that do not coincide with the edges of the weld seam pass through the algorithm, preventing the system from tracking the seam or even causing it to track the wrong lines and thereby drift off the seam.

In general, an expert technician can enter, into the image-processing algorithm, some a priori knowledge to determine whether or not the lines in the T^3V image coincide with the edges of the weld seam. For example, a priori knowledge of the cross-seam pattern can be used to associate a line with the right or left edge, to restrict an identification on the basis of the presence or absence of features between lines or on either side of a line, and/or to identify an edge of the seam on the basis of features in the seam.

The proposed modification of the algorithm would involve one type of such a priori knowledge that can be quantified easily; namely, the width of the seam (or, if the seam has not yet been formed, the width of the gap between the workpieces to be welded together). A seam-width (and gap-width) criterion would be incorporated into the algorithm to determine whether or not a pair of lines represents the weld-seam edges and should therefore be tracked or not tracked, respectively. The distances between lines in pairs of lines to be tracked could be specified within ranges to allow for tolerances in the welding robot, associated tooling, and workpieces. The use of this width criterion could prevent tracking of many false pairs of lines, with consequent decrease in the incidence of inaccurate tracking and increase in confidence in the weld-tracking capability of the robotic welding system.

This work was done by Mark R. Lincir of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*
MFS-29942

Sensor Monitors Force on Filler Wire During Welding

A load cell generates a signal for automatic control of position.

Marshall Space Flight Center, Alabama

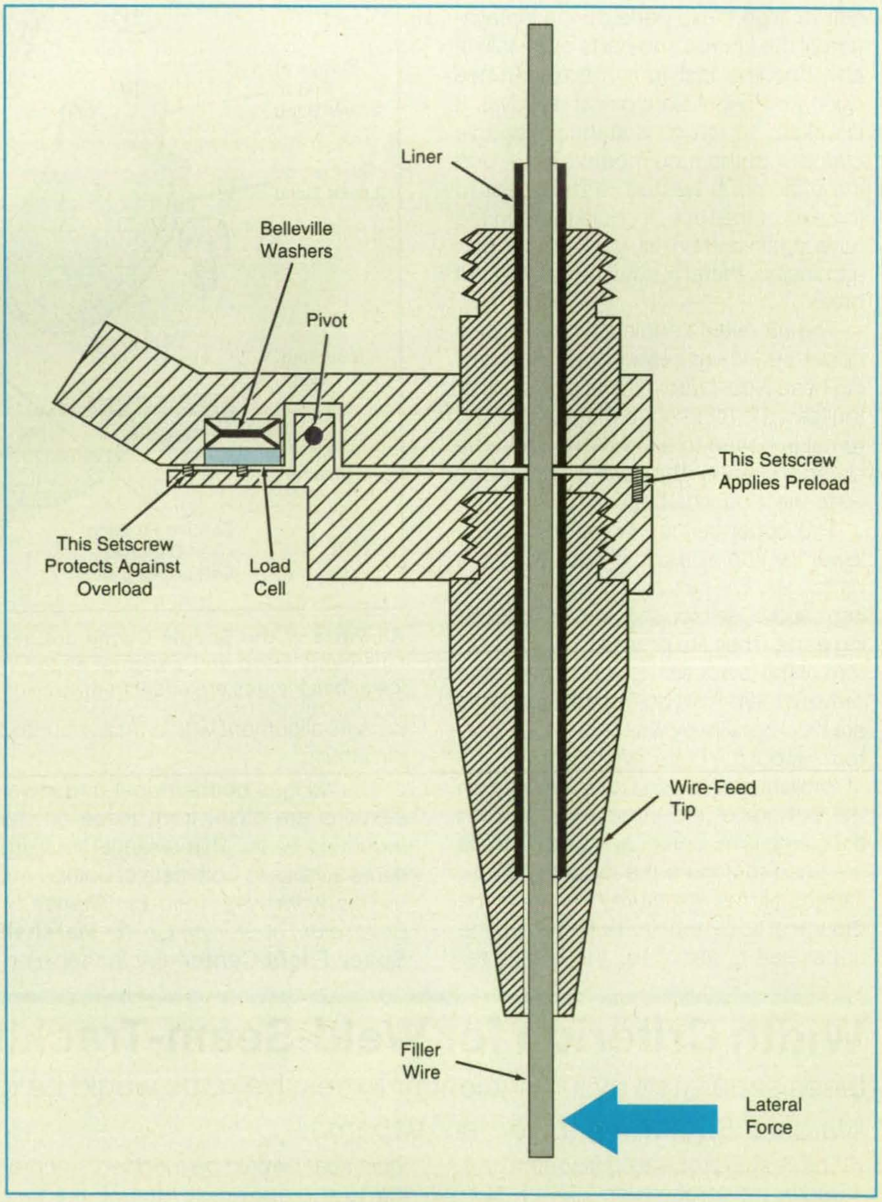
A sensor measures the lateral contact force between a filler wire and a weldment. The output of the sensor is fed as input to a motorized wire-position controller, which strives to maintain the desired contact force.

Previously, a technician attempted to maintain the correct lateral contact force on filler wire by observing the wire at its point of contact with the workpiece. The technician viewed the weld area through a protective filter — necessary because of the intense light of the welding arc — and estimated the lateral contact force from the lateral deflection of the wire. The technician regulated the position of the wire-feed assembly accordingly. This process was inaccurate and inconsistent because of the varying judgment and reaction time of different technicians.

The sensor is built into the wire-feed assembly (see figure). The wire passes through a liner in the assembly on its way to the weld area. A pivoting arm transmits the lateral force on the tip of the wire to the load cell, which produces an analog electrical signal proportional to the force. A setscrew on the arm preloads the cell to a minimum force. Another setscrew prevents the force on the load cell from exceeding a preset maximum value.

This work was done by Tim Morris, Pete Milly, Sr., and Kevin White of Nichols Research Corp. for **Marshall Space Flight Center**. *No further documentation is available.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 22]. Refer to MFS-26216.



The **Pivoting Arm** transmits the lateral force on the tip of the wire to the load cell. Setscrews prevent underload and overload on the load cell.

Mathematics and Information Sciences

Integrating Software Modules for Robot Control

An integration scheme based on a state-variable database enables system reconfiguration.

NASA's Jet Propulsion Laboratory, Pasadena, California

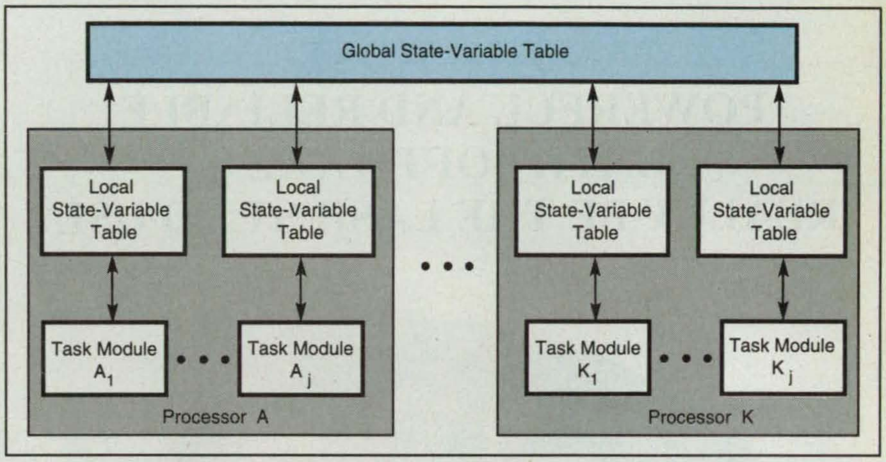
A reconfigurable, sensor-based control system uses state variables in the systematic integration of reusable control modules. The system is designed for open-architecture hardware that includes many general-purpose microprocessors, each of which has its own local memory plus access to global shared memory. The system is implemented in software as an extension of the Chimera II real-time operating system. It provides a transparent computing mechanism for intertask communication between the control modules. It also provides a generic process-module architecture for multiprocessor real-time computation. It has been used to control a robot arm and should prove useful in a variety of other control and robotic applications.

In general, a reconfigurable sensor-based control system consists of many control modules, the input and output ports of which correspond to data required or generated by the module. Control modules can be identified in terms of tasks; for example,

- Read positions of joints from the robot manipulator,
- Compute kinematics,
- Read force sensor,
- Write new torques to robot,
- Log data, or
- Generate trajectory.

Examples of data that might be received or transmitted by a control module include positions and velocities of joints in joint-angle and Cartesian coordinates, the Jacobian matrix of the coordinates, forces, torques, tactile image, and dynamic gains.

The state-variable mechanism of the system uses the global shared memory to exchange data between modules, thus providing communication with a minimum of overhead. A global table of state variables is stored in the shared memory. The variables in the table are a union of all the input- and output-port variables of the modules that may be configured into the system. Tasks (equivalently, modules) do not have direct access to the global table. Rather, the subset of state variables relevant to each task is stored in a local state-variable table (see figure). This arrangement makes it unnecessary to have any synchronization to access the local table. Each task then has a maximum of two accesses per cycle to the global table. The global table is locked for a small and finite time. which in turn leads to a maximum blocking time for any task waiting to read the table, as required for predictable real-time scheduling of the task set.



Local State-Variable Tables assigned to modules are repeatedly updated from the global state-variable table. Values of the variables are transferred into the local table on every cycle of the task. At the end of the task cycle, values are copied from the local table to the global table.

The use of state variables for integration of modules is independent of the specific type and number of processors in the system. Thus, the system can contain any number of processing units made by various manufacturers. Whether several modules run on the same processor or each module runs on a separate processor, the maximum bus bandwidth needed by a particular configuration of the system remains constant.

The primary goal of the state-variable-table mechanism is to integrate reusable control modules in a reconfigurable, multiprocessor system. In a reconfigurable system, a change in configurations can occur either statically or dynamically. In the static case, only the tasks required for a particular configuration are created. In the dynamic case, the union of all tasks required are created during initialization. The tasks required at any given time are then turned "on" by the underlying system in response to an external signal, while other tasks remain "off." When a dynamic reconfiguration of the system is required, the tasks no longer needed are turned "off," and the new tasks turned "on." The structure of the state variable table causes the communication channels between the tasks to be updated instantly automatically when such a dynamic reconfiguration occurs. Modules can be combined into larger ones in a particular configuration to reduce bus bandwidth and CPU power required by the tasks. Such grouping of tasks can also be used to create more-complex modules out of simpler modules, making the functionality of various configurations easier to comprehend.

This work was done by Richard A. Volpe of Caltech and Pradeep Khosla and David B. Stewart of Carnegie Mellon University for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 64*** *on the TSP Request Card.* *NPO-18773*

Parallel-Vector Algorithm for Rapid Structural Analysis

The algorithm exploits the parallel-processing and vector capabilities of high-performance computers.

Langley Research Center, Hampton, Virginia

Researchers in many scientific and engineering disciplines require the solution of systems of simultaneous equations that simulate and predict physical behavior. Currently, the solution of systems of linear equations on advanced parallel-vector computers is a key subject of research with applications in many disciplines. Specifically, to achieve high efficiency in the solution of structural-analysis problems on parallel-vector supercomputers, a revision of the solution procedure and the memory and data management of the structural-analysis codes is required.

For example, the skyline storage technique used in many sequential structural-analysis codes lacks the efficiency of other storage techniques used in the solution of systems of linear equations on vector computers. A new algorithm has been developed to overcome the deficiency of the skyline storage scheme by use of a variable-band storage scheme. The accuracy and speed of this new algorithm was demonstrated in solving large-scale structural-analysis problems on Cray supercomputers.

The algorithm exploits both the parallel and vector capabilities of modern high-performance computers. To minimize computation time, the algorithm performs parallel computation at the outermost "DO" loop of a matrix factorization, which is the most time-consuming part of the solution procedure. In addition, the innermost "DO" loop, representing the most intensive computations of the factorization, is vectorized by use of a SAXPY-based scheme. This scheme enables the use of the loop-unrolling technique, which minimizes computation time.

The parallel-vector Choleski method was used to calculate the static displacements in two large-scale structural-analysis problems: a high-speed aircraft and the Space Shuttle solid rocket booster. For both structural analyses, the static displacements were calculated with high accuracy. The total time needed to solve the equations was small for one processor and was further reduced in proportion to the number of processors. The process of factoring the stiffness matrix for the Space Shuttle solid rocket booster, which formerly required hours on most computers and minutes on supercomputers by other methods, was reduced to seconds by use of the parallel-vector variable-band Choleski method.

This algorithm should give engineers and designers the opportunity to include more design variables and constraints during optimization of structures. It should enable them to use more refined finite-element meshes to obtain improved understanding of the complex behaviors of aerospace structures leading to better, safer designs. Inasmuch as the algorithm is independent of the number of processors, it is not only attractive for current supercomputers but also for the next generation of shared-memory supercomputers, in which the number of processors is expected to increase significantly.

This work was done by Tarun R. Agarwal and Duc T. Nguyen of Old Dominion University and Olaf O. Storaasli of **Langley Research Center**. *Further information may be found in NASA TM-102614 [N92-22649], "A Parallel-Vector Algorithm for Rapid Structural Analysis on High-Performance Computers."*

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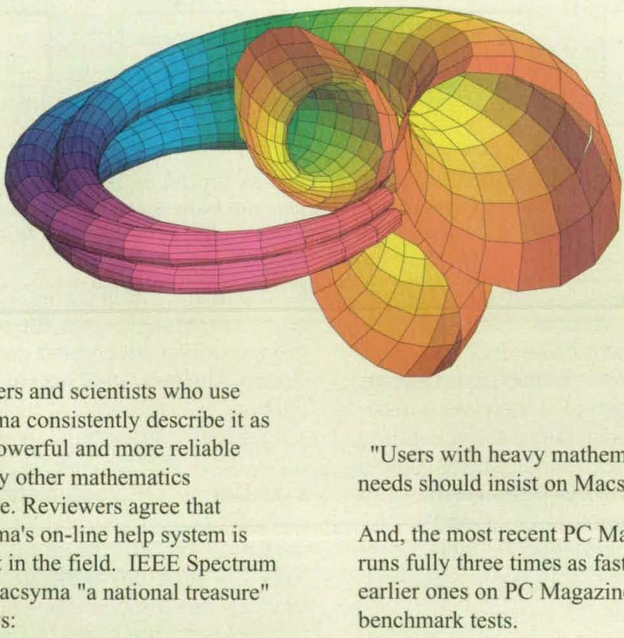


Imaging Genetic Molecules at Atomic Resolution

Molecules would be held in mapped microscopic grooves.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed method of imaging informational polymeric biological molecules (e.g., single- or double-stranded ribonucleic acid, deoxyribonucleic acid, or sequences of amino acids) at atomic resolution would enable the determination of sequences of component monomers about 10^3 to 10^4 times as fast as conventional methods do. The method would accelerate research on the genetic structures of animals and plants. It would also contribute significantly to imaging processes like scanning electron microscopy (SEM), atomic-force microscopy (AFM), and scanning tunneling microscopy (STM) in cases in which it is necessary to locate or identify small specimens on relatively large backgrounds and subtract the background images to obtain images of the specimens in isolation.

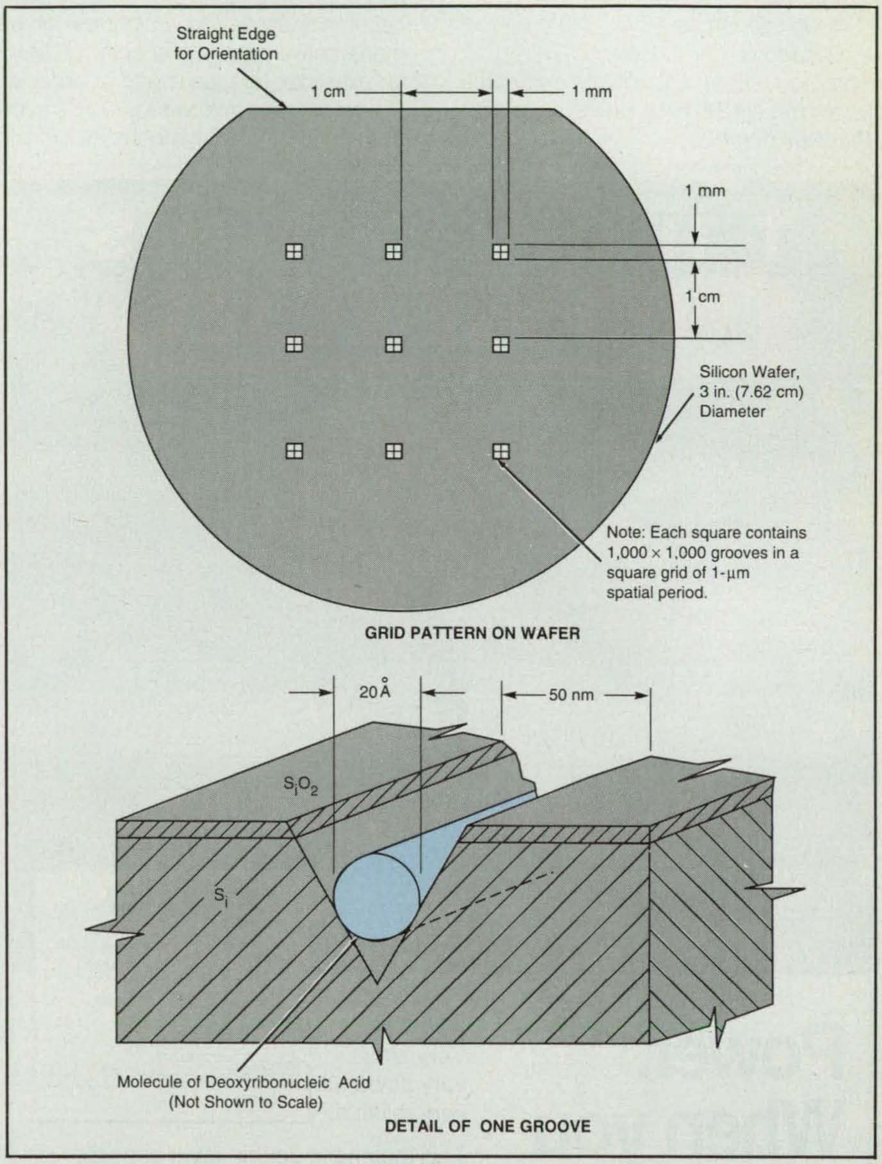
The method would incorporate techniques of either STM or AFM and techniques of micromachining of silicon wafers as in the fabrication of integrated circuits. Specimen biological molecules to be imaged would be held in microscopic V-grooves, each about 50 nm wide, in standard commercial silicon wafers. The grooves would be laid out in a square grid pattern with dimensions as shown in the figure.

Fabrication would begin with polishing the wafers to atomic smoothness (roughness ≤ 5 Å). The upper surface of each wafer would be coated within a thin layer of oxide. The grid pattern would then be formed on and below the oxide surface by a combination of electron-beam lithography and reactive-ion etching. In addition to the grid pattern, a bar code would be etched into the wafer at each intersection between grooves to identify the intersection in terms of its coordinates.

The bar code would be readable by AFM or STM; the control software of the imaging system would use the bar-code data to govern the motion of a two-dimensional translation stage to position the wafer (and, thus, the specimen) repeatably. Thus, an AFM or STM imaging system could quickly scan a large, mostly empty area of the wafer until it encountered a specimen, or it could be directed quickly to predetermined coordinates, or to coordinates of a specimen that had been identified previously.

The steps of a typical application would be the following:

1. Obtain the AFM or STM background image of a chosen small spot of a clean wafer, and record the coordinates.
2. Place a specimen of deoxyribonucleic acid or other molecule of interest on the wafer on that spot, and allow time for the specimen to slide into the grooves under its own weight. Optionally, coax the specimen into the grooves by use of a pulsed electric field.
3. Form the AFM and STM image of the spot. If an acceptable image of the molecule is not obtained, repeat steps 1 and 2 until it is obtained.
4. Digitally subtract the image that shows the molecule(s) in a groove or grooves from the background image that shows the groove(s) only at the same location(s). Process the resulting difference image by use of suitable digital enhancement technique to obtain an image that shows the molecule(s) in isolation.
5. Scan the enhanced image, using a pattern-recognition technique to identify individual nucleotides automatically.



V-Grooves on a Silicon Wafer would be laid out in a square pattern, the intersections of which would be marked to identify their coordinates. Specimen molecules would be held in the grooves for reproducible positioning and scanning by AFM or STM.

This work was done by L. Stephen Coles of Caltech for **NASA's Jet Propulsion Laboratory**. *For further infor-*

*mation, **write in 89** on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

William T. Callaghan, Manager
Technology Commercialization
(M/S 79-23)
Jet Propulsion Labortory
4800 Oak Grove Drive
Pasadena, CA 91109

Refer to NPO-18563, volume and number of this NASA Tech Briefs *issue, and the page number.*

Production of Human Antibodies

Human lymphocytes from any source can be used.

Marshall Space Flight Center, Alabama

A process for making human monoclonal antibodies is based on a combination of techniques that have recently become available. The antibodies can be made active against a specific antigen; for example, tetanus toxoid or hepatitis B. The process involves in vivo immunization of human B lymphocyte cells in mice. The B cells of interest are enriched in vitro before fusion.

The method is potentially applicable to any antigen. It does not rely on use of Epstein–Barr virus at any step. The human lymphocytes can be taken from any source.

The first step in the process is to obtain lymphocytes from human peripheral blood, spleen, bone marrow, or any organ. The purified and washed lymphocytes are subjected to antibody-and-complement, panning, flow-cytometry, or magnetic-bead techniques to deplete unwanted cell populations. The cells are then transferred to mice that bear the severe combined immunodeficiency syndrome mutation. Between 1 million and 100 million cells are transferred, either intravenously or intraperitoneally.

One to 7 days later, the mice are injected with the desired immunogen. One to several booster injections are administered 14 to 90 days after the first immunization. After immunization, the serum of the mice can be subjected to immunoassay for human immunoglobin and antibody to the immunogen.

The mice are sacrificed 3 to 7 days after the final booster injection, and their spleens are removed aseptically. Single-cell suspensions are made from the spleens, and the red blood cells are lysed or removed by use of gradient plates.

The cell suspensions can be fused to appropriate partners by chemical or electrofusion methods. Alternatively, the cells can be cultivated in complete growth medium (CGM) and stimulated by such mitogens as lipopolysaccharide and/or pokeweed for 1 to 14 days before fusion.

The hybrids are then selected in CGM supplemented with hypoxanthine/aminopterin/thymidine and ouabain, which allow only human-source hybridoma cells to grow. The resulting hybridomas are screened by immunoassay for the production of specific antibodies, then subcloned.

This work was done by David W. Sammons of the University of Arizona and Garry A. Neil, M.D., of the University of Iowa for **Marshall Space Flight Center**. *For further information, **write in 29** on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel. Marshall Space Flight Center [see page 22]. Refer to MFS-26174.

These reports, studies and handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Electronic Systems

Comparison of Four FFT-Based Frequency-Acquisition Techniques

A report presents a comparative theoretical analysis of four conceptual techniques for the initial estimation (called "acquisition" in the art) of the carrier frequency of a suppressed-carrier, binary-phase-shift-keyed radio signal. Each technique would be effected by an open-loop analog/digital signal-processing subsystem that would be part of a Costas-loop phase-error detector that would function in a closed-loop manner overall; the term "open-loop" refers only to the frequency-acquisition function, in which neither phase feedback nor frequency feedback would be used. The initial estimate could then be used to initiate the closure of the frequency-control loop in that it would be used to adjust a numerically controlled oscillator to a frequency sufficiently close to the true carrier frequency that it would lie within the pull-in range of the Costas loop.

This work was done by Biren N. Shah, Sami M. Hinedi, and Jack K. Holmes of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Comparison of Four FFT-Based Frequency Acquisition Techniques for BPSK Signals,"* ***write in 78*** *on the TSP Request Card.*
NPO-18569

Neurodynamics With Spatial Self-Organization

A report presents a theoretical study of the dynamics of a neural network that organizes its own response in both phase space (an abstract space associated with neural responses) and in position space (in the sense of the commonly understood meaning of "space" in which the neurons are located). It postulates several mathematical models of the dynamics that include spatial derivatives that represent local interconnections among neurons. It shows how neural responses propagate via these interconnections and how a spatial pattern of neural responses (corresponding, for example, to an image on a retina) might be formed in a homogeneous biological neural network.

This work was done by Michail A. Zak of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Neurodynamics With Spatial Self-Organizations,"* ***write in 72*** *on the TSP Request Card.*
NPO-18595

Materials

Fuel and Oxidizer Filters for the Galileo Spacecraft

A report describes experimental and theoretical studies of the filters in the pro-

pellant (fuel and oxidizer) streams of a propulsion system in the Galileo spacecraft. These studies have contributed to a base of information that is expected to be useful in optimizing the design of filters in the propulsion systems of future spacecraft.

This work was done by Darrell L. Jan, Carl S. Guernsey, and John L. Callas of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Propulsion System Filter Sizing Considerations for the Galileo Spacecraft,"* ***write in 92*** *on the TSP Request Card.* *NPO-18245*

Ruthenium Sesquisilicide: A Promising Thermoelectric Material

A report describes a mostly experimental investigation of the thermoelectric properties of ruthenium sesquisilicide (Ru_2Si_3). According to the report, detailed theoretical considerations suggest that suitably doped Ru_2Si_3 could have thermoelectric figures of merit two or more times as large as that of SiGe.

This work was done by Cronin B. Vining of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Characteristics of a Promising New Thermoelectric Material: Ruthenium Silicide,"* ***write in 26*** *on the TSP Request Card.* *NPO-18617*

Interaction of Hydrogen With Metal Alloys

A report describes experiments on the interaction of hydrogen with a number of metal alloys. X-ray crystallographic data were obtained, concentrations of mobile hydrogen were determined electromechanically, total concentrations of hydrogen were determined by use of a hydrogen analyzer, and the stabilities of hydrides were determined by measuring total concentrations of hydrogen in the specimens both before and after baking the specimens.

The report discusses the relationship between the metallurgical and crystallographic aspects of the structures of the alloys and the observed distributions of hydrogen on charging. It discusses the effect of the formation of hydrides on the resistances of the alloys to hydrogen. It describes an attempt to correlate the structures and compositions of the alloys with their abilities to resist embrittlement by hydrogen (as represented, in the case of each alloy, as the ratio between the tensile strength of notched specimen of the alloy in hydrogen and the tensile strength of a similar specimen in helium).

This work was done by M. D. Danford and J. W. Montano of **Marshall Space Flight Center**. *Further information may be found in NASA TP-3128 [N91-29318], "The Interaction of Hydrogen With Metal Alloys."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 22]. Refer to MFS-27272.

Mechanics

Using Hankel Singular Values To Analyze Weak Vibrations

A report discusses the use of Hankel singular values in identifying mathematical models of the dynamics of a flexi-


UP

ble structure from measurements of its vibrations in the presence of noise. Hankel singular values, or singular values of the system Hankel matrix that represents the dynamics of the structure, are used in determining, from measurements by vibration sensors, the order of the system model, which is the mathematical model of the dynamics of the system (the structure plus any actuators and/or sensors).

This work was done by Wodek K. Gawronski, Fred Y. Hadaegh, and Robert E. Scheid of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "A Hankel Singular Value Approach for Identification of Low Level Dynamics in Flexible Structures,"* ***write in 77*** *on the TSP Request Card.*
NPO-18479

Machinery

More Uses for Configuration Control of Robots

Two papers present theoretical studies of older and newer uses for configuration control, which is a method of resolving and exploiting the redundancy in a robotic manipulator that has more degrees of freedom (typically, more joints) than are needed to perform a basic task. Configuration control was described in "Increasing the Dexterity of Redundant Robots" (NPO-17801), *NASA Tech Briefs*, Vol. 14, No. 10 (October 1990), page 88 and "Redundant Robot Can Avoid Obstacles" (NPO-17852), NASA Tech Briefs, Vol. 15, No. 10 (October 1991), page 86. To recapitulate: The robot has n degrees of freedom. The basic task is to make the end effector of the robot follow a prescribed trajectory in m-dimensional coordinates (where $m < n$). The $r = n - m$ redundant degrees of freedom are used simultaneously to perform an additional task.

In previous studies of configuration control, the additional tasks have involved kinematic optimization of overall trajectories in the joint degrees of freedom.
The additional task is modeled mathematically by use of kinematic functions, which, in effect, define the trajectory in the redundant degrees of freedom.

One of the two present papers —"Configuration Control of 7 DOF Arms"— reviews these concepts, then applies them to a commercial robotic arm that has seven revolute joints that correspond to those of the human arm.

The other paper — "New Goals for Redundancy Resolution Using Configuration Control" — addresses the use of the redundant degrees of freedom to optimize dynamical instead of kinematical aspects of performance.

This work was done by Homayoun Seraji, Mark K. Long, and Thomas S. Lee of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain copies of the reports,* ***write in 28*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquires concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office – JPL [see page 22]. Refer to NPO-18607/18608.

Fabrication Technology

Microwave Dielectrophoretic Levitation in Microgravity

Two reports propose the use of dielectrophoresis in microwave resonant cavities to levitate samples of materials for

containerless processing in microgravity in a vacuum or in any suitable atmosphere. The reports also describe experiments undertaken to verify the feasibility of the proposal.

This work was done by John L. Watkins, Henry W. Jackson, and Martin B. Barmatz of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the reports, "Microwave Positioner" and "Measurement of Microwave Induced Forces,"* ***write in 70*** *on the TSP Request Card.*
NPO-18824

Application of a Control Algorithm to Vertical-Up Welding

A report describes the application of a generalized control algorithm for automatic robotic arc welding in the vertical-up configuration. ("Vertical-up" means that the surface of the workpiece at the point being welded is oriented vertically and the welding torch travels purely upward relative to the workpiece. The vertical-up configuration is particularly important for variable-polarity plasma arc welding.) The generalized algorithm, which is applicable to a variety of welding processes, was previously applied to welding in the downhand configuration. ("Downhand" means that the surface of the workpiece at the point being welded is oriented horizontally, the welding torch faces purely downward onto the workpiece, and the torch moves horizontally with respect to the workpiece.) The generalized algorithm and its application to downhand welding were described in "Method for Automatic Downhand Welding" (MFS-27209), NASA Tech Briefs, Vol. 14, No. 1 (January 1990), page 65.

This work was done by Kenneth R. Fernandez of **Marshall Space Flight Center** *and George E. Cook, Kristinn Andersen, Robert J. Barnett, and Saleh Zein-Sabattou of Vanderbilt University. Further information may be found in NASA TP-3163 [N92-11218], "A Generalized Method for Multiple Robotic Manipulator Programming Applied to Vertical-Up Welding."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
MFS-27274

Mathematics and Information Sciences

Automated Diagnosis of Faults in Antenna-Aiming Systems

A report discusses research directed toward the automated diagnosis of faults in the complicated electromechanical and hydraulic systems that aim the 70-m and 34-m antennas of the Deep Space Network communication system. The basic idea is to develop a system that monitors the outputs of sensors in an antenna-aiming system and that derives indications of faults from those outputs by use of a hybrid of neural-network and signal-processing techniques. The system is to be implemented mostly in software.

This work was done by Patrick J. Smyth and Jeffrey A. Mellstrom of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Fault Diagnosis of Antenna Pointing Systems using Hybrid Neural Network and Signal Processing Techniques (Summary),"* ***write in 16*** *on the TSP Request Card.* *NPO-18651*

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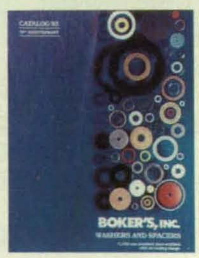

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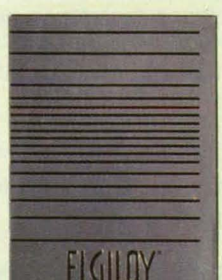

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Your quality needs are our challenge. PMI brochure describes ferrous & nonferrous investment castings to 10#. Many commercial & aerospace applications. 200 airmeltable alloys, with expanded capacity for ductile iron & aluminum. Near netshape, internal complexity, close tolerances, excellent surface finish designed in. Engineering & prototype services complement your engineering team.

Precision Metalsmiths, Inc.

For More Information Write In No. 319

ULTRA-HARD MATERIALS FABRICATION

Insaco's brochure describes the custom manufacture of components in sapphire, ruby, quartz, ceramics of all types including glass-ceramics, alumina, zirconia, carbides, and nitrides. The company routinely fabricates these materials for applications in optics, chemistry, vacuum, bearings, electronics, nuclear, space and medicine. Tolerances are measured in millionths of an inch with surface finishes in angstroms and flatness to fractions of a wavelength. Tel: 800-959-0264; Fax: 800-959-0267.

Insaco, Inc.

For More Information Write In No. 320

CLAMPS

The World of Clamping Catalog 492 describes and illustrates toggle and special clamps with vertical and horizontal hold-down, straight-line, latch, and squeeze action. Spacing products, hydraulic devices, and CAD database are covered along with applications. De-Sta-Co, Troy, MI. Tel: 313-589-2008.

De-Sta-Co

For More Information Write In No. 321

TOOLING COMPONENTS AND CLAMPS

This 500-page catalog contains an assortment of components including toggle clamps, modular fixturing, clamping devices, power workholding, chuck jaws, pins, knobs, drill bushings, leveling feet, power workholding, and much more.

Carr Lane Mfg.

For More Information Write In No. 334

NEW 1993-94 TEMPERATURE MEASUREMENT AND CONTROL CATALOG

Cole-Parmer's new catalog features thousands of products. Measurement instruments include: bimetal, glass, and infrared thermometers; cryogenic monitors; temperature-indicating labels and paint; and RTD, thermistor, and thermocouple meters, probes, and accessories. Data acquisition products include computer interfaces, dataloggers, and recorders. Call: 800-323-4340.

For More Information Write In No. 335

POLYMERS & ACRYLIC MONOMERS

A new, 12-page four-color brochure titled "Engineering Polymers and Acrylic Monomers." Included are polymers and monomers family of products, including Rilsan® 11 and 12 polyimides; Rilsan® powder coatings, Pebax® thermoplastic elastomer resins; Platamid® and Platherm® hot melt adhesives; Platilon® hot melt film; and acrylic monomers. Product description, background, and a sampling of applications are also provided.

Elf Atochem North America, Inc.

For More Information Write In No. 336

LAB/TEST OVENS BULLETIN

A 20-page catalog (Bulletin 3610) describes lab/test ovens by Applied Test Systems. Ovens available in box and split-types, and standards plus custom ovens. Features include: stainless steel shell, uniform temperature, fast heat-up, low power consumption low shell temperature, rigid construction, and temperatures from -300 °F to +1150 °F.

Applied Test Systems, Inc.

For More Information Write In No. 337

ELECTRONIC HARDWARE CATALOG

Broadest selection of hardware for electronic assemblies. 350-page free catalog includes a full range of standoffs, captive screws and nuts, chassis fasteners, handles, ferrules, spacers and washers. Special sections—new, unusual products, metric information and Mil-plating specifications. Full inventory, fast turnaround, samples. Tel: 1-800-237-0013. Fax: 201-661-3408.

Accurate Screw Machine Co.

For More Information Write In No. 338

IR2 INFRARED CONTROL SYSTEM

ANAFAZE

DUAL-LOOP INFRARED TEMP CONTROLLER

Use 1 or 2 infrared sensors coupled to feature-rich ANAFAZE multi-loop PID controllers to remote sense temperature & control machines, devices, processes, etc., accordingly. Applications are anywhere anything is moving, soft, sticky or delicate. Call today for info! ANAFAZE, 334 Western Drive, Watsonville, CA 95076. Phone: 408-724-3800. Fax: 408-724-0320.

ANAFAZE

For More Information Write In No. 339

PROGRAMMABLE POSITION CONTROL

A complete 416-page engineer's guide with specifications, dimensions, and performance data presents brushless servos, microstepping motorsystems, indexers, linear motors and absolute encoders.

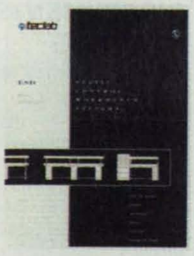
Compumotor Div., Parker Hannifin Corp.

For More Information Write In No. 340

Andover introduces its new 1993 OPTICAL FILTER GUIDE. This extensive 56 page guide features a general and technical section which contains a large amount of information regarding the usage and performance of interference filters and optical coatings. The products section lists Andover's complete line of standard and custom interference filters and optical coatings. Send for your free copy.

Andover Corporation

For More Information Write In No. 341



TECLAB ESD WORKSTATION CATALOG

Kalamazoo Technical Furniture's 8-page 4/color brochure details the *Teclab* line of static protective workbenches, workstation systems, and ESD controlled workstation accessories. Included are color options, product specifications, and various levels of ESD protection available. *Teclab* also offers a Free Planning and Design Service. *Teclab*, the "professional's bench." Tel: 1-800-832-5227. Fax: 616-372-6116.

Kalamazoo Technical Furniture

For More Information Write In No. 342

LEADERS IN INFRARED DETECTORS

EG&G Judson's new 1994 catalog features 53 pages of new and improved products that meet the evolving challenges of the marketplace. Emphasis has been placed on custom engineering services that include:

• Design of specialized detectors • Cooler systems • Preamplifier electronics • Multi channel detector arrays • Space and MIL spec qualified detectors. Tel: 215-368-6901; Fax: 215-368-6927.

EG&G Judson

For More Information Write In No. 343

GPS-SYNCHRONIZED TIMING PRODUCTS

TrueTime's Precision Timing Products catalog features GPS-Synchronized Clocks in rackmount, portable, and board-level configurations. Includes illustrations and product specifications for our complete line of Synchronized Clocks, Time Code Products, and Remote Displays to fit a variety of time and frequency applications.

TrueTime, Inc.

For More Information Write In No. 344

LIQUID LEVEL

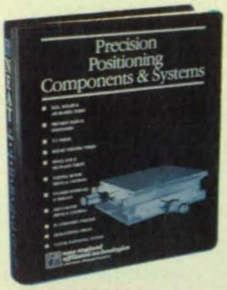
Level Devil System — The most versatile, cost effective, liquid inventory management system on the market today!

- Remote Monitoring/Communication
- Multiple Sites/Multiple Tanks
- Modular/Expandable to 256 I/O
- Real-Time Graphic Software
- Leak Detection/EPA Compliance

From 1 tank to ???, we build each system to your specs—around your budget.

Electronic Sensors, Inc.

For More Information Write In No. 345



PRECISION POSITIONING & MOTION CONTROL

NEAT's 1993 catalog, includes the latest additions to our family of *precision positioning components and systems.* We've expanded our entire product line, which includes: single-axis, multi-axis, rotary, high-vacuum, and air-bearing stages; plus a complementary line of stepping, servo, and linear motor drives and controls. Our fully automated CAD/CAM machining facility enables us to provide custom turnkey solutions. Tel: 1-800-227-1066.

New England Affiliated Technologies

For More Information Write In No. 346

PRECISION GEAR COMPONENTS

Featuring a wide range of gear components in a variety of materials, this 151 page slim-line brochure is the latest from Berg. Designed to complement the Inch and Metric catalogs, it contains Precision Gears & Racks, Gear Assemblies (Inch & Metric), and an extensive technical section. Products include Spur, Helical, Bevel & Worm Gears in various styles and are available in quantities of 1 to 50,000 directly off the shelf or custom made. Tel: 516-599-1700. Fax: 516-599-3274.

For More Information Write In No. 347

APPLICATION OPTIMIZED SILICON PHOTODIODES

A new free catalog of very high performance silicon photodiodes is available from Janos Technology. Quality and performance equivalent or superior to all competitors. Ion implantation technique employed in manufacture of Avalanche, UV/Blue, Wavelength Selective, Position Sensing, and high speed PIN Diodes. Adaptive manufacturing capability allows for optimization to customer-specific applications. Tel: 802-365-7714. Fax: 802-365-4596.

Silicon Photonics
Detector Division of Janos Technology Inc.

For More Information Write In No. 348

UV WAVEGUIDE LASERS

Potomac's compact RF discharge excimer lasers offer unique characteristics including 2000 Hz maximum pulse repetition rate, simplified operation and 110-volt, air-cooled operation. Applications include micromachining of diamond, glass, ceramics, polymers and thin metal films, surface analysis, injection locking, and dye laser pumping. Potomac Photonics, Inc. 4445 Nicole Drive, Lanham, MD 20706. Tel: 301-459-3031. Fax: 301-459-3034.

For More Information Write In No. 349

FREE SPRING PLUNGER

Northwestern's Spring Plungers, Ball Plungers and Hand Retractable Plungers offer many advantages in tooling and production. Quickly, easily installed. Accurately controlled pressures. Positive holding action. Available from stock in a wide range of sizes, spring pressures, types, materials. Free 40 page product guide details the plungers and a large selection of components used in tooling and manufacturing. 3130 Valleywood Drive, Dayton, OH 45429. Tel: 513-298-9994. Fax: 513-298-3715.

Northwestern Tools, Inc.

For More Information Write In No. 305

DIGITAL ERROR ANALYSIS SYSTEM

Yesterday's bit error rate test set has been replaced by today's microprocessor-based BitAlyzer performing thousands of calculations each second and graphically presenting complete bit error rate analysis based on error position. The new BA400 personifies our commitment to *Error Analysis and Beyond.* Address: 3475-D Edison Drive, Menlo Park, CA 94025. Tel: 415-364-1853. Fax: 415-364-5716.

SYNTHESYS RESEARCH, INC.

For More Information Write In No. 351

INSTRUMENTS CATALOG

The 1993-1994 Cole-Parmer catalog features over 1,500 full-color pages and describes more than 35,000 products covering instruments, equipment, and supplies. The catalog features 32 pages of new products, special technical data and conversion factor sections, a newly-organized fittings section, and an expanded chemical resistance chart. Tel: 800-323-4340.

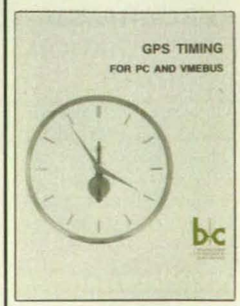
Cole-Parmer Instrument Co.

For More Information Write In No. 352

DESIGN OPTIMIZATION SOFTWARE WITH FEA ENGINEERING BUILT-IN

Free catalog. See why Algor is a world leader in engineering design optimization in which FEA analysis is tightly integrated. Includes solid and surface modeling. Enables engineers to finalize designs before the CAD documentation phase. All popular FEA analyses, including nonlinear. For DOD and UNIX. Adds value to all CAD, CAM and CAE setups. Tel: 412-967-2700; Fax: 412-967-2781.

For More Information Write In No. 353



GPS TIMING FOR PC AND VMEbus

This information folder from Bancomm describes new PCbus and VMEbus board-level Global Positioning System (GPS) Satellite Receivers. These products provide worldwide precision time (100 nanosecond) and frequency (1 Part in 10E7) references inside the host computer.

Bancomm

For More Information Write In No. 354

RECORDING-SYSTEM PORTABLE

A new 8-page, full color technical brochure describes the features and specifications of Gould's new TA11. This 4, 8 or 16 channel recorder integrates signal conditioning, monitor signal capture, chart output and communications into a portable package. Call Gould 216-328-7000.

Gould, Inc.
Test & Measurement Group

For More Information Write In No. 355

RECORDER SUPPORTS 20 Mb MEMORY CARDS

The WindoGraf technical brochure details the newest technologies now available in a high-performance, portable recorder. Now users can monitor signals in real time, capture data to 3 1/2" disks or 20 Mb memory cards and play back to monitor or chart. Call Gould 216-328-7000.

Gould, Inc.
Test & Measurement Group

For More Information Write In No. 356

HIGH SPEED MONITORING/RECORDING SYSTEM

Free technical brochure describes Gould's ES2000 Recording System. Its modular architecture lets users choose monitoring and recording capabilities to match application needs. Record high speed and digital signals at the same time, monitor on a real-time display and output to thermal array recorder. Call Gould 216-328-7000.

Gould, Inc.
Test & Measurement Group

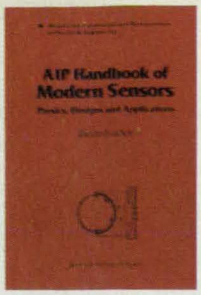
For More Information Write In No. 357

SIGNAL CONDITIONERS

Now get the most accurate signals in more ways than one, with Gould's high-performance signal conditioners. Measurements can be no better than the quality of the signal conditioning. And Gould does it better than anyone else. Call Gould 216-328-7000 for free brochure.

Gould, Inc.
Test & Measurement Group

For More Information Write In No. 358



AIP HANDBOOK OF MODERN SENSORS

A current and comprehensive reference work on the theory, design, and practical implementation of various sensors for scientific, industrial, and biomedical applications. Presents the physical principles of sensing as well as state-of-the-art technological advances. Includes hard-to-find reference data on the properties of numerous materials and sensing elements.

AIP Press—Books of the American Institute of Physics

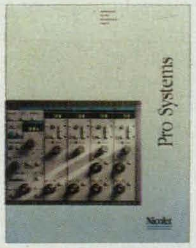
For More Information Write In No. 359

ELECTROMAGNETIC DESIGN SOFTWARE

The legendary Vector Fields suite of software, including the TOSCA, ELEKTRA, and OPERA packages, combines classical finite element techniques with user friendly interactive graphics for high accuracy 2D and 3D simulation and design of all types of electromagnetic equipment.

Vector Fields, Inc.

For More Information Write In No. 360

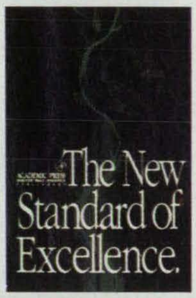


NICOLET PRO DIGITAL STORAGE OSCILLOSCOPES

The Nicolet Pro Oscilloscopes offer two or four channels, with 256K per channel, in both eight- and twelve-bit versions, at sampling speeds from 1 MS/s to 200 MS/s. Users can examine the key events in their waveforms without paging or scrolling, by a unique display that shows the max-min boundaries of up to four 256K records.

Nicolet Measurement Instruments

For More Information Write In No. 381



ACADEMIC PRESS DICTIONARY OF SCIENCE AND TECHNOLOGY

Containing definitions for more than 133,000 terms, this new dictionary has been praised by the American Library Association as an "Outstanding Reference of 1993." As reviewed in *Booklist/Reference Books Bulletin*: "...Captures the terminology of today and gives modern definitions...highly recommended."

Academic Press, Inc.

For More Information Write In No. 361

HIGH GAIN DETECTOR FOR LIGHT MEASUREMENT

A new SHD-1 data sheet describing the SHD033 High Gain Silicon Detector for low level light measurement in any optical unit is available from IL. The device provides the gain of a photomultiplier with the stability of a silicon photodiode. The SHD033 is used with the IL1700 Research Radiometer/Photometer. Address: 17 Graf Road, Newburyport, MA 01950. Tel: 508-465-5923. Fax: 508-462-0759.

International Light, Inc.

For More Information Write In No. 362

MULTI-SCREEN DISPLAY FOR WORKSTATIONS AND PCS

ComputerWall™ magnifies and splits computer imagery across a 2 x 2 or 4 x 4 array of projectors. Analog interface automatically synchronizes to workstations or PCs. Compatible with all software. Exactly duplicates real-time, true color images up to 1280 x 1024 pixels including text, graphics, animation or full-motion video. Built-in routing switcher in ComputerWall+ displays split or single screen images from six sources.

RGB Spectrum

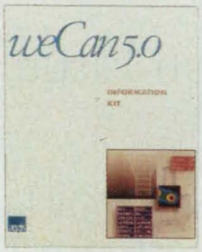
For More Information Write In No. 363

THE LINK BETWEEN COMPUTER GRAPHICS AND VIDEO

RGB/Videolink® video scan converters transform images from a computer, radar, or FLIR sensor to broadcast standard video (NTSC or PAL) for taping, projection or teleconferencing. Video can be overlayed with computer generated graphics. Applications include training, simulation, archiving and signal transmission. GSA Contract #GS03F2032A.

RGB Spectrum

For More Information Write In No. 364



NEW FEA DESIGN AND ANALYSIS SOFTWARE

WeCan 5.0 is an integrated engineering design analysis package running on PCs and workstations. It is a full-featured, 3-D package developed by Westinghouse Electric Corporation over a 20 year period and used to simulate and visualize a wide range of static, dynamic and thermal design problems. FREE INFORMATION KIT; FULL WORKING DEMO AVAILABLE. CALL 412-826-3470.

Aegis Software Corporation

For More Information Write In No. 365

10 MHz FREQUENCY STANDARD

The FS700 is a 10 MHz LORAN-C based frequency standard that provides the long term stability of a Cesium clock with NIST traceability. The standard timebase has short term stability of 10^{-10} (the optional timebase has 10^{-11}). External timebases are quickly and easily calibrated from the front panel, which also provides an analog voltage proportional to the phase difference. An 8 foot active antenna and 100 ft of cable are included for installation.

Stanford Research Systems

For More Information Write In No. 366

COPY FOR PXS SPOTLIGHT

Kevex X-Ray's PXS line of portable x-ray sources feature the x-ray tube, high voltage power supply, control electronics and heat exchanger in a single compact package. Each PXS unit is operable from a low level DC source, either 12 VDC or 28 VDC. An optional controller is available to control and monitor target voltage and beam current.

Kevex X-Ray

For More Information Write In No. 367

MOTION CONTROL HANDBOOK

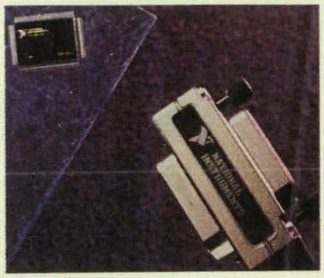
Four-color 44-page book sets forth the basic DSP fundamentals; motion controller, servo filters, background PLC, circular interpolation moves, blended moves, cubic spline moves. Includes: 10 programming examples, summarizes PMAC commands and variables with G-code section. Details PMAC's options and accessories, as well as hardware and software.

Delta Tau Data Systems, Inc.

For More Information Write In No. 368

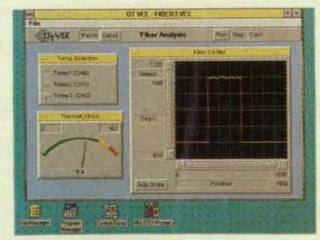
New on the Market

National Instruments, Austin, TX, has unveiled the TNT4882™, the first single-chip IEEE 488.2 Talker/Listener **GPIB interface**. It features a 100-pin Plastic Quad Flat Pack surface-mount package, built-in IEEE 488.1 compliant transceivers, a 32-bit DMA transfer counter, and programmable high-speed synchronous data transfer rates up to 8 MB/sec.
For More Information Write In No. 700



STG Inc., Encino, CA, has introduced Axiom-SA, the first **CASE tool** to fully integrate requirements analysis, requirements tracing, and documentation production into a Windows environment. Axiom-SA allows users to create and validate structured analysis models, trace fulfillment of critical requirements, and generate documentation in standard or customized formats.
For More Information Write In No. 702

Data Translation, Marlboro, MA, has created DT VEE™ for Windows, a **graphical programming language** for use with the company's data acquisition boards. DT VEE enables real-world application development that is faster, easier, and more intuitive than textual language coding. Based on HP VEE, the package adds menus and icons that mimic the functions found on high-performance plug-in data acquisition boards.
For More Information Write In No. 706

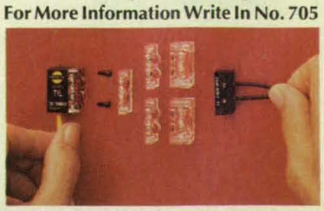


Wilcoxon Research Inc., Gaithersburg, MD, has created the model 797T dual-output piezoelectric accelerometer, an advanced **semiconductor temperature sensor** that permits simultaneous measurement of both vibration and temperature. The sensor operates from 2 to 120 °C with a sensitivity of 10 mV/°C; the accelerometer has a sensitivity of 100 mV/g and can be used over a frequency range of 1 to 12,000 Hz.
For More Information Write In No. 704

The first commercial **color electroluminescent (EL) display** has been released by Planar Systems Inc., Beaverton, OR. The EL640.350-DA1 displays eight colors on a very-high-contrast black background in a 640(x2)x350 format. Typical power consumption is 16 W. Based on a new nonreflective structure, the display achieves high contrast without a costly contrast-enhancing filter. It consists of an EL glass panel and control electronics assembled into a compact (226 mm x 153 mm x 20 mm) package for easy mounting.
For More Information Write In No. 701

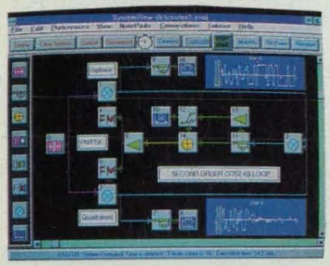
SmartCAM Advanced 3D Machining™ Version 3.5, from Point Control Co., Eugene, OR, **creates CNC processes** for both 3-axis simultaneous milling operations and 4- and 5-axis positioning-milling operations. The software will create tool path for ruled, spun, lofted, translated, form patch, Coons, and draft surfaces. Capabilities include automatic cavity roughing, planar cutting, and gouge correction.
For More Information Write In No. 703

The TINY•EYE™ line of **miniature photoelectric sensors** has been introduced by Tri-Tronics Co., Tampa, FL. The sensors feature unique "quick-change" optical block lenses, allowing them to be used in any mode (proximity, convergent, retroreflective, polarized retroreflective, or fiber optic). They provide a 500 µsec. response speed and an 18" proximity, 20' retroreflective, and 25' through beam range.
For More Information Write In No. 705



New on the Market

RGB Spectrum, Alameda, CA, has introduced a **video mixer** that combines the output from two imagers or computers (up to 1280 x 1024 pixels) to produce a composite high-resolution picture. SynchroMaster™ 300 combines foreground and background images through use of a chroma or luminance key, or a weighted sum algorithm. It features a frame store synchronizer that allows mixing of synchronous images from disparate sources.
For More Information Write In No. 712



SystemView, the first **dynamic simulator** designed for personal desktop use and featuring comprehensive analog and digital tools, has been released by ELANIX Inc., Westlake Village, CA. A high-level conceptual design and analysis engine embedded in an intuitive and completely visual design environment, SystemView supports multi-rate and parallel simultaneous systems, and internal or external data sources and sinks. It provides a new approach to designing analog-digital filters, and discrete time and continuous-time Laplace linear systems.
For More Information Write In No. 711

The Chromalux® 476, a **lighted indicator** for aircraft applications, is offered by Korry Electronics Co., Seattle, WA. The 3/8" x 1" press-to-relamp indicator is retrofitted easily into aircraft currently using Korry's 476 design. It features "on" and "off" contrast that eliminates legend shadows in extreme sunlight, a brightness greater than 250 foot-Lamberts across the entire message space, and chromaticity control to within 0.2 units. Performance is enhanced for night vision imaging system and aviation colors.
For More Information Write In No. 707

The HT600 **data acquisition and analysis system** from Hi-Techniques Inc., Madison, WI, combines Motorola and Intel processors for high-speed, high-resolution digitizing of signals from electrical transients, sensor outputs, electronic circuits, and communications networks. It features measurement accuracy of 1% and sampling rates from 100K sample/sec. to 200 Megasamples/sec., with memory sizes from 2K to 32 MB per channel.
For More Information Write In No. 708

The ProRack line of nonshock-mounted, rationally-molded, EIA standard 19" **rack cases**, is now available from Hardigg Cases, South Deerfield, MA. Lighter than conventional wood cases and more durable than vacuum-formed plastic cases, the stackable ProRack features fully recessed hardware, a one-piece molded shell, and a conic-fit frame. Prices start at $200.
For More Information Write In No. 713

Instron Corp., Canton, MA, has created a noncontacting **video extensometer** that provides high measurement accuracy without touching specimens. The 2663 series protects delicate specimens from harm and eliminates errors that can result from using clip-on extensometers. Because the meter measures the actual gauge length of the marked specimen, users can accurately measure extension in units of length and percentage strain.
For More Information Write In No. 710

Hyperception, Dallas, TX, has released a free demonstration disk featuring Hypersignal-Windows AMPS (Acquisition, Measurement, Processing, and Storage), a **PC-based instrumentation package** for Windows 3.1. The demo is based on AMPS Version 1.20, which provides a spectrum analyzer, two oscilloscopes, a digital recorder, and a snap-in PC filter design.
For More Information Write In No. 709

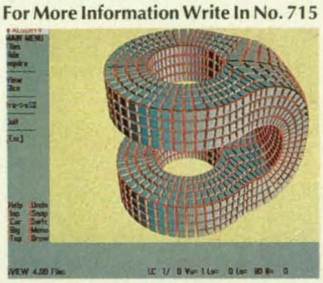
New on the Market

The Indy™ **desktop computing system** from Silicon Graphics, Mountain View, CA, couples a digital color video camera, a host of digital interactive media capabilities, and advanced 3D graphics and imaging. Priced from $4995, Indy supports more than 1300 applications from leading software developers.

For More Information Write In No. 718

Hexagen, from Algor Inc., Pittsburgh, PA, is the first **software** for building three-dimensional hexahedral, eight-node "brick" finite element models from a quadrilateral surface mesh paving. The program makes mechanical design easier and more accurate. It can use a mesh from virtually any CAD/CAM/CAE source, such as AutoCAD, Pro/ENGINEER, or Algor's Superdraw II, and is compatible with Algor's fully-parametric NURBS-surface modeler.

For More Information Write In No. 715



Vermont Photonics Inc., Westminster, VT, has introduced the ELCOMAT HR, an **electronic autocollimator** offering high resolution and accuracy for metrology standards work. It features a 0.005 arc second resolution with a 300 arc second measuring range. Absolute accuracy over the entire range is ±0.03 arc seconds. The remotely controlled unit is available as a one- or two-axis instrument with computer interface.

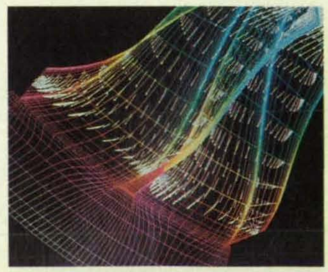
For More Information Write In No. 717

VRontier Worlds, Stoughton, WI, has developed a low-cost **software program that achieves a true virtual reality environment** shared by two users at once, connected by telephone. The application works on standard copper telephone wire at very high speeds. Priced at $29.95, the program operates on PCs with at least a 386 processor chip, a modem, and a mouse.

For More Information Write In No. 719

Intel Corp., Santa Clara, CA, has released a **scalable UNIX operating system** that runs on its Paragon™ XP/S supercomputer. The OSF/1 AD MK system, in contrast to other parallel UNIX systems, is transparently distributed across the computer's nodes. This allows Paragon computers to scale to thousands of nodes without introducing bottlenecks or requiring half-way measures.

For More Information Write In No. 720



The Hysol 4200 Spray Tool™, from Hysol Engineering Adhesives, Seabrook, NH, is the first portable **hot melt adhesive applicator** available in the US. The handheld gun sprayapplies melted SprayPac™ adhesive, covering up to 250 square feet per pound of adhesive. The easy-to-use Spray Tool will operate effectively at any angle (even upside down) and can be loaded in seconds without downtime.

For More Information Write In No. 716

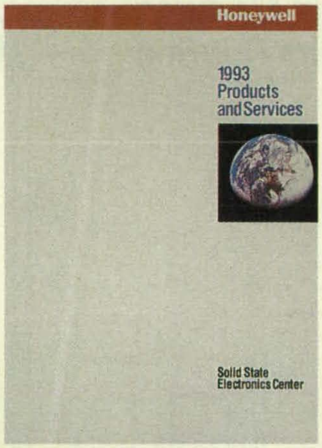
Northern Research and Engineering Corp., Woburn, MA, has released VISIUN™ and VISIUN-2FR™, **computational fluid dynamics (CFD) software** for the analysis of three-dimensional, unsteady, compressible flow in turbomachinery. The Navier-Stokes-based CFD codes can be used to analyze compressible flow in radial turbines and even axial machines. VISIUN provides solutions within a stationary or rotating frame of reference, while VISIUN-2FR provides a two-frame-of-reference solution, accommodating both rotating impellers and stationary vanes.

For More Information Write In No. 714

New Literature

A new data book from Honeywell Inc., Minneapolis, MN, describes the company's complete **integrated circuit** product lines and services. The book describes SRAMs, ROMs, nonvolatile RAMs, multichip modules, gate arrays, analog arrays, and high-temperature and sensor products. Also included are sections on Honeywell's VLSI design system and foundry services.

For More Information Write In No. 722



A 20-page technical report from TopoMetrix Corp., Santa Clara, CA, describes sources of **scanning probe microscopy (SPM)** image artifacts and their interpretation. SPMs characterize materials by providing quantitative 3D images of surfaces in the X, Y, and Z axes at atomic and near-atomic scale. The report identifies the sources of artifacts, those measurements differing from actual sample surfaces, to enable proper interpretation of SPM data.

For More Information Write In No. 725

A free booklet from Rotork Controls Inc., Rochester, NY, discusses the prevention of **pneumatic actuator corrosion**—the primary cause of actuator failures. The publication highlights basic pneumatic actuator operation, applications, types of corrosion that adversely affect actuators, and measures effective against them.

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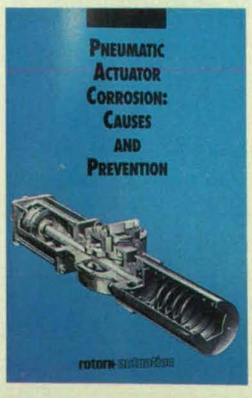

Keithley Instruments Inc., Cleveland, OH, has published three new application booklets on **test and measurement instruments**. "General Measurements" contains notes on topics ranging from locating short-circuits in circuit boards to measuring power line harmonics; "Semiconductor Measurements" focuses on zener diode characterization and parametric testing of semiconductors; and "Low Level Measurements" features cryogenic liquid level sensors and insulating materials measurement techniques.

For More Information Write In No. 723

Analog Devices, Norwood, MA, has released its *1993 Applications Reference Manual* for **analog, mixed signal, or DSP design** where real-world signals must interface to electronic systems. The technical articles, application notes, tutorial material, and design ideas in the 1344-page collection are reprinted from a wide variety of sources. Topics range from fundamentals such as noise and grounding through advanced subjects such as multichannel systems.

For More Information Write In No. 721

The Dynapower Corp., Burlington, VT, is offering a reprinted article entitled "Survey of DC Current Measurement Techniques for High Precision Supplies." It investigates **measurement techniques** typically found in precision DC, current-regulated power supplies used in particle accelerator applications. It explains why the degree of precision required, the maximum current, and the operating environment should govern the choice of a current measurement device.

For More Information Write In No. 724

Audio Precision Inc., Beaverton, OR, has released a 35-page booklet highlighting its System One **audio testing** products and services. System One is used for design, test, and maintenance of power amplifiers, analog and digital audio signal processors, distribution amplifiers, routing switchers, broadcast transmitters, satellite communications circuits, recorders, microphones, and loudspeakers.

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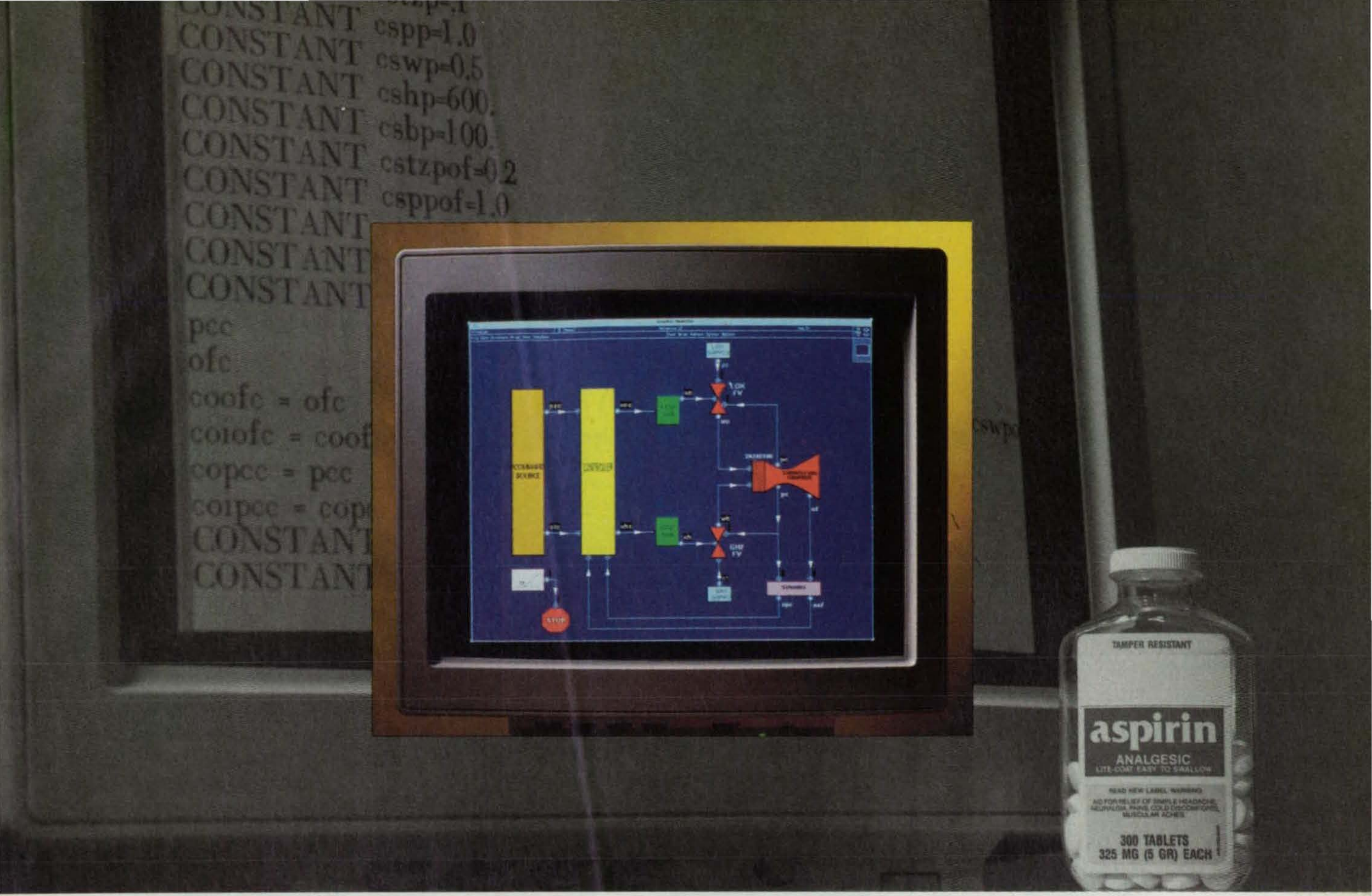
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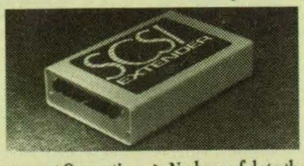

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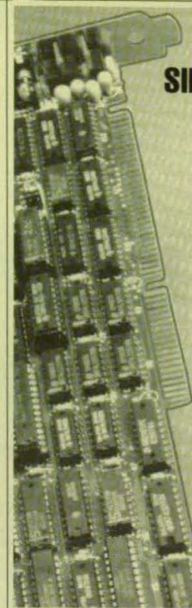

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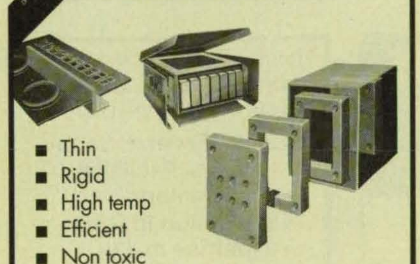

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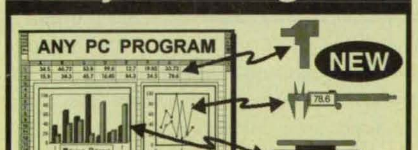

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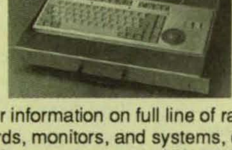

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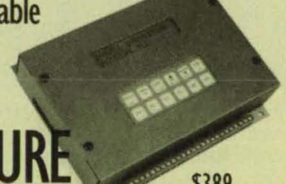

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